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## THROUGH THE EYES OF THE EDITOR

Thomas E. J. Shanahan has recognized the importance of dental physiology as it is applied to artificial dentures. This approach to the problems of occlusion suggests possible answers which might be overlooked otherwise. He points out that the confusion in the thinking about chewing cycles is the result of differing interpretation rather than a real difference. He distinguishes between masticating cycles and excursions of the mandible in such a way as to clarify the various interpretations. He also suggests a technique for applying this information to the problem of occlusal adjustment.

Robert B. Sloane applies the sciences of anatomy, physiology, and laws of mechanics to vertical dimension and jaw movement. He emphasizes that vertical dimension is not an isolated problem, but is definitely integrated with other factors in the mouth in which the dentures must function.

Victor H. Sears calls attention to the fact that occlusion is a problem common to orthodontics, periodontics, and prosthodontics. He asks that there be a better exchange of ideas on occlusion between these various specialties, and points out some definitions and basic principles in occlusion which could be helpful.

Victor H. Sears proposes some axioms regarding occlusion and occlusal schemes. He then suggests a series of simple tests of these axioms. The acceptability of the axioms should be determined by the reader after he has made the experiments.

M. M. DeVan discusses the basic principles of impression making. His analysis of the quality of the support furnished by mouth tissues is particularly good. He says that rest impressions are plausible but may not suffice for retention and function. He points out the importance of stability and its relation to horizontal forces and concludes that the impression phase of denture construction has been overemphasized.

C. H. Blanchard has written of the importance of the use of the fingers to determine denture outlines. His article is so cleverly written that even though we do not agree completely with him, we do recommend it. There is merit in certain applications of the procedures he proposes.

N. I. Goldberg and A. Gershkoff use a Vitallium implant to fix lower dentures. They are enthusiastic about their results, so far. They describe their new technique which seems to have advantages over those used previously.

Edward J. Sullivan, in discussing the paper by Goldberg and Gershkoff, is more conservative in his enthusiasm. He suggests that this work is still in the clinical experimental stage. He agrees that their new technique is better than previous techniques, but he is still unsatisfied. He makes the very important point that there is, as yet, insufficient histologic information about dental implants and their effects.

W. E. Pernell gives a short history of dental implantation. He describes the technique he uses, and reports good success. However, he emphasizes the fact that this type of work is still in the experimental class.

Luzerne G. Jordan discusses the importance of cooperation between the oral surgeon and the prosthodontist in rendering prosthetic service. He suggests many things

which could be done by both specialties which would result in better denture service for patients.

Jerome C. Strain has investigated the influence of dentures on taste perception. The physiology of taste sensation is thoroughly reviewed. It forms a most important background for this special problem. The article will supply a much needed reference on a neglected phase of denture service.

Wm. J. McCracken has made extensive tests to evaluate a relatively new denture base material. The activated methyl methacrylates have intriguing possibilities when used for this purpose. He reports less curing shrinkage than occurs with heat-cured acrylic, but warns that the material needs further testing.

Alexander Leff discusses precision attachments for partial dentures. He points out the places where they may be indicated or contraindicated. He describes their relation to saddle design and tissue support. He suggests that they are not as complicated to use as is generally believed. He describes a simplified procedure for their use.

George W. Hindels discusses the distribution of the masticatory load through extension saddle partial dentures. His analysis of the relation of the various types of impressions to this problem is quite logical. He suggests a procedure which will carry out the principles arrived at in the analysis.

Vincent R. Trapozzano and Gordon R. Winter emphasize the importance of mouth examination and roentgenograms in making diagnoses for partial dentures. They point out the factors of general health which are of importance to the successful treatment of mouths which contain both natural and artificial teeth. They discuss design of partial dentures with the object of preserving the remaining teeth and their foundations.

Luzerne G. Jordan writes of factors which are of importance to successful partial denture restorations. Many of these have been neglected in routine practice. He indicates his techniques for specific situations. The techniques are simple and sound. The indications for their use are clear and well defined.

Nathaniel A. Olinger reviews the etiology, anatomy and physiology of cleft palates in the first part of his paper. This could well be used for reference. The second part describes the technique for the construction of an appliance for a Class V cleft palate. The appliance restores the vomer, and the pharyngeal portion is attached to the partial denture by a pin lock hinge.

James V. Giordano writes of methods for evaluating knowledge and ability in the field of prosthetics. It is of particular interest to State Board examiners but should be of concern to all who practice prosthetics. There is a definite trend in dental education toward emphasis on basic sciences. This trend is occurring at the expense of training in the practical application of the principles of the basic sciences. The trend threatens prosthetic dentistry as we know it now. We must be on guard. The more comprehensive examination suggested by Dr. Giordano for State Board Dental Examiners may be a partial answer of control.

—Carl O. Boucher

# DENTAL PHYSIOLOGY FOR DENTURES

## The Direct Application of the Masticating Cycle to Denture Occlusion

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THE patient's use of his dentures is the concern of every dentist doing prosthetic work. In order to attain complete dental use, the dentures must be built to conform not only to the patient's physiologic pattern of chewing, but to the patient's lateral and protrusive excursion movements as well. The lateral and protrusive actions in grinding are attributed to the nervous tension of modern living. It is now recognized that these two factors should be included in all occlusal restorations, replacements, and treatments.

The direct use of the physiologic movements for occlusion opens the way for prosthodontists to increase a patient's denture function. This phase of prosthetic work can only be acquired by first studying dental physiology and then by learning how to apply the knowledge thus obtained to the various masticating movements.

The direct use of the mandibular excursions and the use of an adjustable articulator provide two methods for eliminating premature contacts which may occur when patients grit and grind their denture teeth. Tensions brought about by normal aggravations frequently carry over into the evening and often cause sleepless nights. The occlusal movements that take place under such tension, while not functional in nature, must none the less be provided for in the establishment of denture occlusion.

The study of dental physiology has produced a new occlusal movement known as the masticating cycle.

Dental physiology, as a division of oral physiology, treats of the function of the teeth as an organ of the body during mastication. It also includes the functions of the tissues of the teeth and their supporting structures. By recognizing the teeth as an organ (dental), we can readily differentiate between the occlusal movements of the teeth during mastication and the occlusal movements of the nonmasticating excursions.

There are many mandibular movements. In some of these movements, the lower teeth make contact with the upper teeth; in others they do not. The movements that involve tooth contact are divided into two classes, masticating and nonmasticating. In the masticating movements, the mandible moves in cycles, and the occlusal contacts are made at the end of the cycles. Although

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recognition of masticating cycles is relatively new in dentistry, research has been done in this country by Boswell[1] with his mandibulograph and mandibuloscope and by Kurth[2] with the stroboscope which confirms an earlier work of Hildebrand[3] of Stockholm in 1931. The nonmasticating movements are well known in dentistry as the lateral and protrusive excursions.

The difference between the cycles and the excursions, as pointed out by Kurth, is that each respective movement is in a different direction and on a different plane. The general direction of the excursion is in a horizontal plane, while the general direction of the cycle is in a vertical plane.

Any history of dentistry will show the tremendous efforts that have been made to reproduce lateral and protrusive excursions with articulators in the construction of full upper and full lower dentures. Today, we have such outstanding instruments as the Hanau, House, Stansbery, Precision Coordinator, and others. Although these articulators vary in detail and construction, their main function is the reproduction of the lateral and protrusive excursive movements which are similar to the nonmasticating movements found in the mouth.

At present, there is a tendency to extend the use of the adjustable articulator beyond the scope of complete dentures into other fields where natural teeth are involved, namely, partial dentures, mouth rehabilitation, and bridgework, as well as for a guide in the treatment of periodontal conditions. The use of the adjustable articulator in dentulous and partially dentulous cases is questionable, mainly because the lateral excursive movements of the natural teeth differ radically from those of the edentulous cases. In natural teeth, the lateral occlusal movement is below centric occlusion, as was shown by Pleasure[4] and Kurth.[2] In edentulous cases, the lateral movement of the mandible is above the centric occlusion position.

A glance at Fig. 1, adapted from Kurth's essay, indicates a front view of the various mandibular movements.

Line *A* represents the general horizontal direction of the upper arm of an adjustable articulator during a lateral movement.

Line *B* represents the general horizontal direction of the occluding planes of a natural upper tooth that guides the mandible. This indicates that the lateral occluding excursions of the mandible are below centric occlusion.

In order to apply dental physiology treatment to dentures, it is necessary not only to learn the various masticating movements, but also to develop the means for applying the treatments.

Masticating cycles move in a general vertical direction. They begin at the rest position (*R*), move downward, outward, and backward to engage food, and then move upward, forward, and inward to centric position (*C*). The cycles so formed are known as Boswell cycles.

On the other hand, Jankelson[5] has shown, by the use of the oscillograph and cinefluorograph, that there is another type of cycle used in the mastication of food. This cycle does not end at centric position, but terminates at or close to the rest position. In an untrained subject, a bite of apple was chewed forty-seven times, followed by two swallowings, without a single occlusal contact

being recorded. It was not until the subject swallowed the third time that the first occlusal contact was made.

In the work of Boos,[6] a Bimeter was used to determine the vertical level of greatest biting pressure, and it was found to be in the area of the rest position. This substantiates Jankelson's findings that in masticating hard and tough foods interposed between the teeth, occlusal contacts do not take place.

Kurth found, in studying the occlusal movements from a horizontal plane (Fig. 2), that the excursions functioned within the Gothic arch anteriorly to the centric position. The masticating cycles, on the other hand, functioned outside the Gothic arch posteriorly to the centric position. (The dotted line divides the tooth anteroposteriorly at centric position.) The illustration of the upper right second molar is an example of the way the lower right molar distobuccal cusp functions during the excursions and cycles. The heavy arrow indicates the occlusal segment of the masticating cycle.

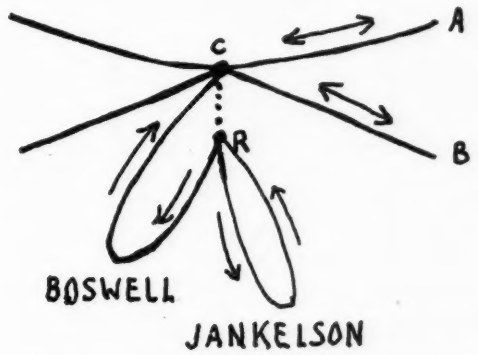


Fig. 1.—Drawing after Kurth's stroboscopic picture, indicating the directions of two nonmasticating and two masticating movements. Line *A C*, direction of articulator above centric excursions; Line *B C*, direction of natural tooth below centric excursions. Boswell's cycles terminate at centric occlusion. Jankelson's cycles terminate at the level of rest position.

This masticatory cycle has limited chewing power, but it takes precedence over the other occlusal movements in establishing occlusion. The force of this cycle is strong enough to dislodge a denture or to traumatize a natural tooth when the occlusal surfaces are not conformed to function. It is therefore necessary to eliminate premature contacts from the path of this cycle as it moves into centric position. Since neither the movement nor the force of this cycle can be reproduced, it is necessary to record the occlusal pattern of this movement directly in the mouth in wax.

Boswell has contributed to the study of the function of dental physiology in his statement: "Mandibular action and guidance are almost wholly neuromuscular while the temporomandibular joints are primarily accommodative or adaptive mechanisms for assisting or fitting the body of the mandible, with its teeth masses, to its work." He illustrated, by means of his mandibuloscope, that the mandible during masticating cycles is depressed on the working side

to effect a paralleling of the occlusal surfaces for an efficient shearing action. The teeth on the opposite side are elevated almost to occlusion during the paralleling of the working sides. This movement is known as the Boswell movement. To a lesser degree, the same phenomenon takes place when the patient closes into a wax check bite for a crown or an inlay; this results in a premature contact on the completed restoration.

Brudevold,[7] who used small strain gauges under the two bicuspids and the first and second molars on the same side of an upper denture, said: "It is interesting to note that in chewing the very tough shoulder of beef, the number of chews on the second bicuspid was greater than the number on the first molar. For the brittle carrot, on the other hand, the number of chews on the first bicuspid numbered less."

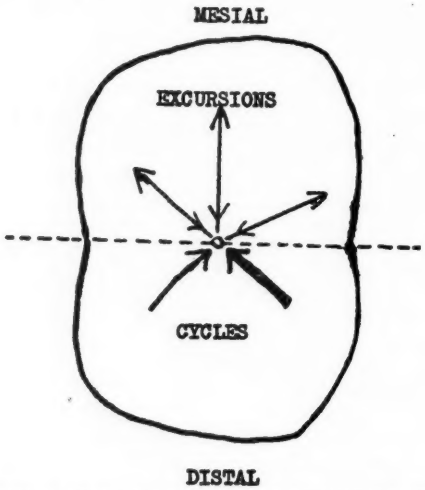


Fig. 2.—Drawing indicating that the lateral and protrusive excursions are anterior to centric position, while the occlusal segment of the masticating cycle is distal to centric position (occlusal view).

In the study of dental physiology, the functional changes that take place in the dental organ as age advances are easily recognized. In advanced age, cusps present a problem in the construction of complete dentures because there is no guide except the broad statement that the lower the age, the higher the cusp or, conversely, the higher the age, the lower the cusp. Since the dental organ undergoes changes in keeping with the other organs of the body, it is an accepted hypothesis that the mandibulograph[1] of a 15-year-old boy with natural teeth would be quite different from that of a man of 65 years with all his natural teeth. The boy's masticating cycles are clear and well defined in outline and terminate at centric position, while those of the adult are found to be indefinite and rambling and only occasionally terminate at centric position.

Recently Payne[8] has shown the appropriateness of high cusps over flat teeth in the mouth of a 15-year-old girl who required complete dentures. No doubt the sequel to this case will be that in later life this patient will require very low cusps or flat occlusal surfaces.

As the dental organ changes in cyclic function due to age, the cycles tend to terminate in excentric positions. In natural teeth having strong bony structure, the premature contact points of both upper and lower teeth are abraded, and the surfaces are conformed to the cyclic function. When the bone support is weak, the premature contact produced in mastication traumatizes the teeth. If the cusps of full denture teeth are not conformed to the cyclic movement, the dentures will be subjected to traumatic lateral thrusts through the premature contacts. Assuming that the occlusion of complete denture cases has been balanced and the premature contacts of the lateral excursions have been removed on the fully adjustable articulator, it is still necessary for complete occlusal treatment to conform the cusps to the masticating cycles.

In applying dental physiology to dentures the primary objective is to find a method for utilizing our present knowledge of the subject. The main purpose is to conform the occlusal surfaces of the denture teeth to the function of chewing at the various age levels and to the physiologic changes that accompany each age. Still another objective is to conform the occlusal surfaces of the denture teeth to the nervous habits caused by grinding in both lateral and protrusive excursions.

It should be pointed out that the method of application is subordinate to the function or movement under consideration. Various methods may be introduced for reproducing or utilizing a single function or movement. For applying lateral and protrusive movements to complete denture occlusion, a method in use is that of transferring check bites from the mouth to the fully adjustable articulator for the reproduction of these movements. The direct method consists of having the patient perform these movements directly in the mouth in wax, and then the teeth are conformed to these excursive movements.

Another purpose of this paper is to discuss the means of conforming the occlusal surfaces of the denture teeth to the function of mastication. Masticating cycles are the principal mandibular movements in chewing food, and therefore they take precedence over other occlusal movements in establishing denture occlusion.

## CENTRIC OCCLUSION

Centric occlusion is the principal occlusal position, and it is the terminal position for both the excursions and the Boswell cycles. This occlusal position must be established before the teeth are conformed to the various mandibular movements. It must coincide with the centric relation at the proper degree of vertical opening, and it should be in balance. Occlusal contacts are at a maximum in centric occlusion. The masticating value of natural teeth is determined by the number of occlusal contacts. According to the Dahlberg[9] method, normal natural teeth should have thirty-two contacts in centric occlusion, twenty-six points for the masticating teeth and six points for the incisors. The distal side of each cuspid is counted as a masticating unit. Detailed methods for determining the occlusal surface contact area have been developed by Dahlberg and Yurkstas and Manly.[10] Wax was used to record the surface contact area.

## OCCLUSION IN EXCURSIONS

In order to establish occlusion during the lateral excursive movements for complete and partial dentures, it should be remembered that the excursions of complete denture cases are above centric occlusion and that the excursions of partial denture cases are below centric occlusion. This indicates that the lateral excursions that are acceptable for full dentures would not be acceptable for partial dentures (see Fig. 1). Excursions above centric occlusion apply to complete dentures only. Occlusion may be established by either the direct or the indirect method. The indirect method, as mentioned previously, is the transfer of check bites, taken in the mouth, to an adjustable articulator and the reproduction of the excursions on the instrument.

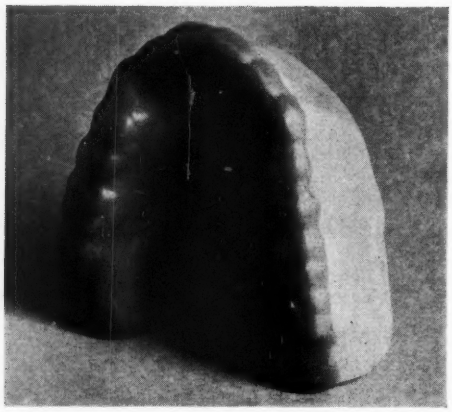

Fig. 3.—The preparation of a completed full upper denture for taking an occlusal record with baseplate wax.

The direct method is accomplished by having the patient perform the excursions directly in the mouth, with the full lower denture functioning against a sheet of wax placed over the occlusal surfaces of the full upper denture (Fig. 3). Excursions below centric occlusion apply to natural teeth and to partial denture teeth. Since there are no articulators which will reproduce these below centric excursions, the direct method is indicated. After the partial dentures are completed and balanced in centric occlusion and the tests for premature contacts have been completed in the mouth, the following method is used for removing these premature contact points and establishing lateral occlusion.

## CORRECTION OF CONTACTS IN EXCURSIONS

Adapt a half sheet of baseplate wax to the palate and over the entire occlusal area and bend the wax upward to cover the buccal and labial surfaces of the teeth. Direct the patient to close into centric position to seat the wax over the occlusal surfaces. Then direct the patient to move the lower teeth from side to side in the lateral excursions for one or two minutes. Chill the wax record and

remove it from the mouth in order to detect the perforations. Large perforations and tears indicate extensive premature contacts. These contacts are marked in the mouth and reduced by the use of suitable stones. This procedure is continued until all the premature contacts have been eliminated.

After the paths to centric occlusion have been cleared, it will be noted that the excursions are made with ease, and the wax record is free of perforations. The routine, minute pin points are tolerated. The patient's name is written on the record together with the date and type of movement obtained, and the record is filed with the patient's history for future comparison with subsequent records.

### CORRECTION OF CONTACTS IN THE MASTICATING CYCLES

The application of dental physiology, in the form of masticating cycles, to full and partial dentures produces an occlusal effect on the wax record quite unlike that of centric occlusion and lateral excursions in that by comparison there is a minimum of occlusal contact. At the beginning of the chewing process and as soon as pressure is applied, the mandible drops down on the working side to parallel the upper teeth, while the opposite side tends to close up. Attention is directed to the fact that during chewing, pressure on the teeth is not evenly distributed, but is confined to the premolars and the first molar.

Fig. 4.—An occlusal wax record of a lateral excursion of a full upper and full lower denture.

The application of the masticating cycles to complete and partial dentures also consists of placing a half sheet of baseplate wax over the palate, covering the occlusal surfaces, and turning the wax over onto the buccal and labial surfaces to prevent the wax from moving while chewing is going on. The patient chews into the wax as in chewing food for a minute or two. The wax is then chilled, removed from the mouth, and checked for perforations. As was done in the excursions, the premature contacts are marked through the wax on the teeth (Fig. 4) and removed. This process is continued until all premature contacts have disappeared. This cyclic record is also preserved with name, date, and type of movement written on the wax. It is filed for future reference.

As part of a patient's record every complete denture case and partial denture case should have this information on file so that, when a patient returns for a periodic examination, a new record can be made quickly for comparison with the original, and any changes in occlusion can be recorded (Fig. 5).

After dentures have been in use for a number of years, a patient may manifest evidence of a change in the function of the dental organ. Since these changes occur slowly, it is advisable that patients realize the importance of periodic examinations. Tests may indicate that a deep cusp is no longer appropriate because the organ does not function directly to centric occlusion between the narrow confines of deep buccal and lingual cusps. As the physiologic function changes, premature contacts become evident, and the approach to centric occlusion must be widened. Advancing age brings premature contacts to cusp teeth, and it becomes necessary to continue lowering the angle of the cusps until a flat occlusal surface is developed. It is for this reason that the occlusal surfaces of the teeth should be selected according to the patient's age, health, and dental function. To repeat, a high cusp for the young, a low or flat cusp for the aging is the general rule.

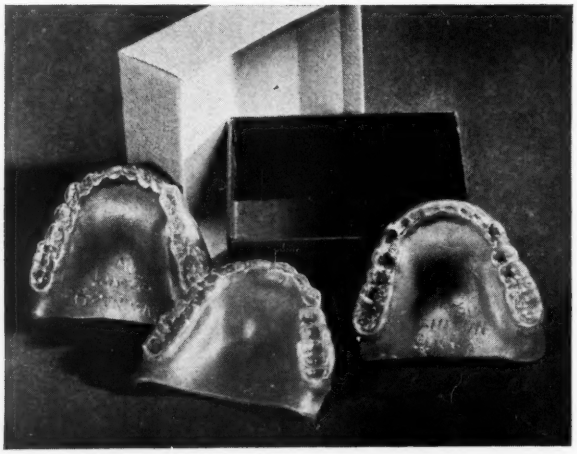

Fig. 5.—Occlusal wax records of centric occlusion, the masticating cycles, and the lateral and protrusive excursions of a complete case ready for filing.

## SUMMARY

Dental physiology is a division of oral physiology which treats of the functioning of the teeth as an organ during mastication of food. Masticating cycles are the principal movements during mastication. Cycles terminating at centric position are the movements used in conforming the occlusal surfaces of denture teeth to chewing function. Since it has been established that patients grind their teeth in nonfunctional movements for longer periods than they do in functional chewing, both the lateral and protrusive excursions must also be provided for.

I would like to close with the recommendation that the direct method of recording the occlusal movements of the masticating cycles and the lateral excursions be used to conform the occlusal surfaces.

## REFERENCES

1. Boswell, J. V.: Practical Occlusion in Relation to Complete Dentures, J.PROS.DEN. **1**:307, 1951.
2. Kurth, L. E.: Mandibular Movements in Mastication, J.Am.Dent.A. **29**:1787, 1942.
3. Hildebrand, G. Y.: Studies in the Masticatory Movements of the Human Lower Jaw, Berlin and Leipzig, 1931, Walter De Gruyter & Co.
4. Pleasure, M. A.: Practical Full Denture Occlusion, J.Am.Dent.A. and Dental Cosmos **25**:1606, 1938.
5. Jankelson, B.: Physiology of the Masticating Apparatus, Unpublished paper read at the 1951 meetings of the American Denture Society and the Academy of Denture Prosthetics.
6. Boos, R.: Intermaxillary Relations Established by Biting Power, J.Am.Dent.A. **27**:192, 1940.
7. Brudevold, E.: Chewing Forces of a Denture Wearer, J.Am.Dent.A. **43**:45, 1951.
8. Payne, S. H.: Posterior Occlusion in Duplicate Dentures, J.PROS.DEN. **1**:322, 1951.
9. Dahlberg, B.: The Masticating Effect, Acta med. Scandinav., monograph, p. 65, 1942.
10. Yurkstas, A., and Manly, R. S.: Measurements of Occlusal Contact Area Effective in Mastication, Am.J.Orthodontics **35**:185, 1949.
11. O'Rourke, J. L., and Minor, L.: Oral Physiology, St. Louis, 1951, The C. V. Mosby Company.

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# KINESIOLOGY AND VERTICAL DIMENSION

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THE usual evolution of a scientific principle is the unscientific acceptance of a "known fact," followed by an exposé of cause and effect. The cause and effect are then promulgated into principle form. The application of established principles of science has resulted in a vast number of technical advances.

Kinesiology is a science which, by definition, recognizes and utilizes the principles or laws of related sciences. Bowen's[1] definition is as follows: "Kinesiology is the science concerned with muscular movement in man, and endeavors to explain in terms of anatomy, physiology, and established laws of mechanics, the way in which movement is affected."

A workable theory of muscular action was formulated by Hippocrates, Aristotle, and Galen which stood for 1,500 years. Then Leonardo da Vinci, the first of a series of physiologists, added his contributions. Borelli, in the seventeenth century, clarified the mechanical principles of muscular movement. In the nineteenth century, Duchenne, Braune, and Fischer[2] made their contributions to the understanding of the action of muscles on joints. Bowditch contributed the "all or nothing" principle of muscular contraction. Sherrington demonstrated the principle of reciprocal innervation as applied to antagonistic muscular groups, indispensable for explaining skilled motion. In the early twentieth century, Hill[3] experimented with the thermodynamics of muscular activity. Eggleston, Meyerhof, and Lundsgaard worked to explain the chemical nature of muscular recovery and contraction. More recently, Engelhardt and Lubynova have shown a direct enzymatic action between myosin, the structural protein of muscle, and adenosinetriphosphate, a compound possessing high energy. Gyorgi and his group are investigating most actively the colloidal nature of the muscle proteins, myosin and actin, and are attempting to formulate the cycle of contraction and relaxation in thermodynamic terms. Kinesiology has a historic, as well as scientific, background. Kinesiology has established the fact that muscle groups can be retrained. It has been proved conclusively that corrective exercises for purposes of inducing postural changes must result in an increased tonus in one set of muscles and in a shortening of the muscles themselves. Muscles held in a shortened position, and in use in that shortened position, will shorten and accommodate themselves to the new length with the establishment of normal tone. The antagonistic muscles will become proportionately stretched and accommodate themselves to their new length and tone. The joint affected will have a new rest position. Adjustments of this type are common.

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The fact of muscular and joint accommodation is something that comes into our daily lives with complete and unconscious acceptance. The new soldier learns an erect carriage. Women adjust from flat to high-heeled shoes. The athlete, the dancer, the high-stool bookkeeper, all learn new postural attitudes. The manufacturer of artificial prostheses restores lost function to injured and impaired limbs, with attendant muscular accommodation.

Dentistry has no inviolate aloofness to the universal laws of science. We have no right to maintain the integrity of any professional pronouncement which does not withstand scientific scrutiny.

Much has been written and more has been said about "the problem of vertical dimension." But vertical dimension is not an isolated problem. As an inlay must be integrated to function in the mouth for which it is constructed, so must the "vertical dimension problem" be viewed in context and not arbitrarily treated as an individual entity. The relationship between the mandible and the maxilla is not a consideration of two halves of a chewing apparatus in space. It is a complicated relationship which must be examined carefully before any decision is reached as to what the free-way space is, or what alterations can be tolerated in the maxillomandibular relationship. The problem of vertical dimension is by no means one of muscular accommodation alone, for we now know that muscles can be oriented to function well at altered lengths and that joints can gain new rest positions. There must be other factors then responsible for the failures that have long been attributed solely to an alteration in the vertical dimension. Much of the confusion regarding vertical dimension arises from the inability to orient cases in treatment to the axis of an articulator in the same fashion as the jaws are related to the mandibular axis. The mandibular axis, a fixed factor of mandibular function, must be taken into consideration if we are successfully to plan and execute therapeutic dental treatment. If the vertical dimension of a restoration is altered without reference to the mandibular axis, the restorations will not articulate in centric closure in the mouth as they do on the articulator. The error will be more or less conspicuous depending upon the extent of the alteration of the maxillomandibular relationship. It is conceivable that errors of articulation can give rise to a variety of complaints. These complaints can, in turn, be attributed to an alteration of the vertical dimension, but they are not primarily due to an encroachment on muscular function.

Let us assume that a restoration has been inserted without reference to the mandibular axis and that the axis of the instrument used in the construction of the restoration is so displaced as to produce a prematurity in the molar area. It may be possible for the patient to bring the jaws together in spite of the occlusal prematurity. The mandible will pivot on the point of initial contact, and an excessive force will be required to bring the teeth together. With the teeth in apposition, the heads of the condyles will be pulled from their cradled positions in the glenoid fossae. Symptoms may arise from the excessive muscular force required to approximate the jaws and its attendant fatigue, the molar prematurity, or the alteration of the normal joint function. These symptoms occur

when the vertical dimension is altered, but are not due per se to the change in the maxillomandibular relationship. These are factors related to the lack of similarity between the mandibular axis and the axis of the articulator. This example may be expanded to include the more complicated symptomatology which arises from a consideration of the complexities of articulation in eccentric excursions.

We should recognize, too, the role the propriopathic preceptors play in a consideration of an alteration of vertical dimension. Here again, we find many examples of accommodation through training that serve as guides to indicate that muscular adaptations can occur in our chewing apparatus. The piano player learns the value of controlled percussion, the blind man to read Braille, and the dentist lightness of hand. A patient soon learns when the teeth will touch and can accommodate to a new rest position, with the establishment of a new free-way space, if no unnecessary obstacles are placed in his way.

The science of kinesiology has shed tremendous light on the interrelationship of anatomy, physiology, and laws of mechanics as they pertain to muscular movement and accommodation in man. These facts are as applicable in dentistry as elsewhere in science and, if evaluated objectively, can be extremely helpful in our understanding of many of the problems that confront us.

## REFERENCES

1. Bowen, Wilbur P.: Applied Anatomy and Kinesiology, ed. 6, Philadelphia, 1949, Lea & Febiger.
2. Braun, G. L.: Kinesiology From Aristotle to the Twentieth Century, Research Quarterly, Am. A. Health, P. E. & Rec. **12**:163, 1941.
3. Hill, A. V.: Living Machinery, New York, 1927, Harcourt, Brace and Company, Inc.

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# OCCLUSION: THE COMMON MEETING GROUND IN DENTISTRY

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PROGRESS in the sciences depends largely on the use of appropriate terms. This is true in dentistry. Symbols in general or terms in particular do not make us think clearly nor speak accurately but without appropriate and unambiguous symbols what thinking and speaking we do is bound to be fuzzy.

Let us be sure, then, that we agree on the meaning of the term "occlusion." To occlude means to shut. An occluded blood vessel is one that is shut; an occluded dentition is one that is shut. Opposing teeth out of contact are out of occlusion. This might seem so simple that we need not mention it at all, but a study of the literature reveals that some of the writers do not even distinguish between "occlusion," "articulation," and "relation."

Articulation of teeth signifies gliding contact of opposing tooth surfaces. It is, therefore, only a phase of occlusion, and we should not use it to stand for occlusion itself any more than we should use the symbol "New York" when we mean "America" or the symbol "paragraph" when we mean "literature."

Even more confusion is seen in the careless use of the word "relation." This as a dental term should be reserved for the jaws. We can have occlusion of the teeth in or out of the mouth without reference to the jaws, and we can have relation of the jaws with or without teeth. Thus we have tooth occlusion and jaw relation, and they mean quite different things. There must be this sharp distinction if we are to think and speak and write clearly.

## MISLEADING CLASSIFICATIONS

Now curiously enough, at the same time that we failed to distinguish between our terms, we have set up arbitrary and illogical distinctions in dentistry as well as in the sciences generally. Of course there are logical specialties in all general fields of science, but there is the constant danger that the specialist will view his work as something unrelated to the work of others. This is one of the weak parts of our way of thinking.

Ever since the time of Aristotle we have been inclined to segregate knowledge into compartments as though one set of factors could belong exclusively to physiology and another to anatomy. We speak of mind and body as though they were independent of each other which they are not. And so it is but an extension of the same way of thinking that we come to look on such divisions

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as orthodontics, periodontics, and prosthodontics as being separate fields of dentistry and to look on dentistry itself as a division existing largely apart from such fields as biology and physics. Thus we overclassify facts into isolated orbits when we should see them rather as factors common to other systems. This is still true in the matter of tooth occlusion. But since basic principles are invariable, we should be able to demonstrate that all procedures based on these principles are related.

Let us now consider tooth occlusion as viewed within the specialties of orthodontics, periodontics, and prosthodontics, and then indicate how a knowledge of one can help us with the others.

## ORTHODONTICS

Although one aim of the orthodontist is to make the rows of teeth in a dental arch look even, usually a more important aim is to align them so that they will function efficiently throughout the life of the patient. This requires much more than causing certain points on the teeth to fall into their respective opposing depressions. It requires that the patient be able to glide the teeth in the various articulations without injury to the tooth-supporting structures.

Without benefit of orthodontics, nature may so tilt and turn the teeth that they function throughout the various chewing strokes without overloading the investing tissues. Then again, she may fail to do so. When she so fails, the case becomes one of both orthodontics and periodontics.

Scientific orthodontics includes articulation in all of the chewing movements as well as the mere fitting of cusps to centric occlusion. Even more, it requires harmonizing the tooth arrangement with the temporomandibular situation. Orthodontic treatment can hardly be called scientific without finding the patients centric jaw relation and the possible eccentric relations. It is difficult to believe that by holding occluded casts in the hand the orthodontist can gain any adequate knowledge of how to harmonize the tooth inclines with the jaw movements or to arrange the teeth in centric occlusion in harmony with centric jaw relation. The plotting of graphs also seems inadequate to meet these requirements.

If the orthodontist would arrange duplicates of the natural teeth on an accurately adjusted articulator as the prosthodontist does, he might in advance of orthodontic treatment test the various possible arrangements. By means of suitably formed dowels, he could remove any of the teeth for trial positions and replace them in their original positions at will. He might thus learn whether any satisfactory alignment of all teeth could be made. If not, his tests might well indicate whether or not any teeth and if so which teeth could be removed to advantage. He might easily see what modifications of tooth form should be effected to assure harmonious articulation. This would cause his practice to overlap into the field of prosthodontics first and then into periodontics. In 1938 your essayist outlined a procedure of this kind. Such a procedure shows clearly that occlusion is the common meeting ground in dentistry.

## PERIODONTICS

The periodontist seeks to harmonize the occlusal surfaces of the teeth with the patient's jaw movements. The teeth may be out of proper alignment for lack of orthodontic treatment or even because of it. Nature does more or less arranging of the teeth to harmonize with the jaw movements and sometimes arrives at an arrangement that is functionally satisfactory even though not esthetically so. Orthodontic treatment for aligning the teeth more evenly may increase the cuspal interference so that the patient needs the services of the periodontist.

Usually the patient's periodontic problems do not become acute until in his 30's when the interference due to steep tooth inclines causes greater horizontal forces on the teeth than their aging supporting tissues will tolerate.

Regardless of whether the teeth are even or irregular in arrangement, nature wears away more or less of the surfaces that might interfere with smooth articulation. But when there is an absence of abrasives in the food, as there usually is in our country today, the interference to the easy glide of the teeth in eccentric jaw movements causes horizontal pressures on the tooth roots in excess of nature's ability to withstand them. Then follows a train of evil consequences which cause the loss of teeth and alveolar process unless the tooth interferences are removed. We see the investing tissues break down especially in those mouths with steep cusp inclines. When nature fails to reduce the cusp steepness sufficiently through the interposed abrasives during chewing, it becomes the duty of the dentist to do so.

The periodontist has the problem of apportioning the occlusal load according to the ability of the investing tissues to withstand the pressures. Especially should he reduce the inclination of cusps whose supporting value against horizontal component force is small, whether because the roots are short or the investing tissue is weak. He may also reduce the total occlusal area in order to reduce the amount of pressure under vertical force.

In estimating the degree of horizontal force on a tooth, the periodontist is aided by carbon paper spotting and by a feeling of movement in the tooth socket as the finger is held on the buccal or labial side of tooth and gum during the various articulations. But he should do more. He should mount study casts on an articulator adjusted to the individual jaw motions of the patient. Only then can he view the various occlusions from the lingual side. On the adjusted articulator he can make the alterations of cusp form. From the altered casts the operator could then make a template to be used on the natural teeth according to the technique well known in machine-shop practice of spotting with lamp black.

## NATURAL AND ARTIFICIAL DENTURES

Although the mechanical principles are the same for natural and artificial dentures, it might be well to point out some of the differences we should keep in mind when applying these principles:

1. Individual natural teeth are held by fibrous attachments in sockets of bone, whereas prosthetic restorations rest on slippery surfaces.

2. Individual natural teeth move slowly, whereas prosthetic restorations can be dislodged instantaneously.

3. Individual tooth movement is possible with natural teeth, whereas with prosthetic restorations the whole denture moves as a unit.

4. Malocclusions of natural teeth, especially in young patients, may exist for years without apparent injury, whereas the same malocclusions of complete artificial dentures normally manifest themselves in a few hours.

5. Malocclusion of a natural tooth is detrimental to its immediate investing tissues, whereas malocclusion of a tooth on a complete artificial denture is detrimental to the supporting tissues at other sites than the ones underlying the malocclusion.

6. Horizontal pressure from the lingual side of a natural upper crown on the left side, for example, has no effect on the teeth of the right side, whereas such pressure on a prosthetic restoration tends to push the teeth on the right side horizontally.

7. Vertical pressure on the lingual cusp of a natural tooth on the left side, for example, has no effect on the teeth of the right side, whereas such pressure applied lingually of the ridge crest on prosthetic dentures tends to press the right side of the restoration more firmly toward the tissues, or such vertical pressure applied buccally of the left ridge crest tends to teeter the dentures, lifting them from the supporting tissues of the right side.

8. Premature contact of incisors in protrusion has no immediate effect on the natural posterior teeth, whereas such contact of prosthetic restorations tends to lift the posterior teeth of both dentures from their supporting ridges.

9. Premature contact of second and third molars has no immediate dislodging effect on the other natural teeth, whereas such contact of prosthetic restorations tends to slide the lower denture anteriorly and to lift the anterior teeth from their supporting ridges.

10. Natural teeth in centric occlusion meet their antagonists throughout the entire extent of the dental arch, whereas in the case of complete artificial dentures in centric occlusion, only those teeth nearest the center of the denture foundation should meet their antagonists.

With so many differences between natural and artificial dentures, we should not be at all surprised that the occlusal forms need to be different also. And here again the experiences of prosthetic workers with their special occlusal forms can suggest certain modifications of natural teeth to solve some of the mechanical problems of orthodontics and periodontics. We should keep in mind that whereas a natural tooth in its socket is somewhat like a post in the ground, an artificial denture is more like a teacart on board ship. With this thought in mind we shall presently point out some of the problems of occlusion for complete artificial dentures and indicate how these problems may be solved by the design and placement of special occlusal forms.

Before that, however, it should be pointed out wherein the requirements of a dental articulator differ for use with natural and artificial dentures.

## DENTAL ARTICULATORS

In the orthodontic field and for most cases in the periodontic field, we should mount duplicates of the natural teeth on a dental articulator. This articulator should be adjusted to carry the teeth accurately through paths similar to the paths followed by the natural teeth in the patient's mouth. Any error of the articulator adjustment would render less satisfactory the plan for mechanical treatment of the natural teeth. It is clear that in orthodontics and periodontics the dentist needs an articulator that can be adjusted with great accuracy.

In the field of complete artificial dentures the same rigid requirements would hold if natural cusp forms were used. However, with the prosthetic plan of occlusion now to be described and advocated, we need adjust only the downward and forward inclinations of the condyle guides. With the newer and more scientific treatment of prosthetic occlusion we can meet both the immediate and the future requirements of the patient with the use of less intricate articulator mechanisms.

## PROSTHODONTICS

Since nature has produced no kind of denture that rests on the mucous membrane of the mouth, we dentists have no suitable natural pattern to copy. We must devise an original plan of occlusion to meet the special situation of the edentulous mouth. In devising this plan of occlusion we must adhere to mechanical principles, and it should not be at all surprising that this adherence will call for occlusal forms differing from the natural forms supported in sockets.

While both natural and artificial dentures serve similarly as stops to prevent too great closure of the jaws, there are three other mechanical functions that should be served differently in natural and prosthetic teeth.

In natural teeth, the same parts serve these three functions: (1) the cutting and mashing of food, (2) balancing of the dentures in protrusive and lateral jaw movements, and (3) the filling of the vestibule. These three functions should be served also with the artificial forms. However, by departing from nature's design we can actually separate the teeth into three distinct parts according to the three functions. We can thus obtain the maximum function of each part without compromising the other two parts. For instance, the part that does the cutting and mashing of food need not be interfered with in any way by the part that does the balancing of the occlusion nor by the part that merely fills the vestibule.

The advantage of being able to assign one part of the tooth exclusively for the work of chewing makes the design of this part more simple and more satisfactory than is the case in the anatomic scheme where the other functions must be involved. There is the further advantage that when we speak of the part discharging this one function exclusively, our thinking and our discussions can be clear and concise.

Let us give names to the three different parts of a posterior tooth so that we may know exactly what we are talking about: The surface of the tooth that accomplishes the work of chewing we shall call the *working occlusal surface*, the part that is used for bilateral or protrusive balance is known as the *balancing occlusal*

*surface,* and the part used merely to complete the contour of the tooth and fill the vestibule without occluding with its opposite is the *subocclusal surface.* In our discussion, unless otherwise indicated, the term "occlusal surface" will mean the "working occlusal surface."

For complete artificial dentures the design, extent, and placement of the working occlusal surface are of prime importance. With its intelligent management we can enhance the stability, comfort, and efficiency of our complete restorations. Its isolation for separate consideration may well suggest a broad approach to the problems of occlusion in orthodontics, periodontics, and prosthodontics.

An important requirement for the working occlusal surface of natural or artificial teeth is that its extent be restricted to a degree which the supporting tissues can tolerate. In the case of artificial dentures, the edentulous alveolar ridges ordinarily tolerate less force than do natural dentures. Therefore, we should make the extent of the working occlusal surface on artificial dentures less than that of natural ones.

Another requirement is that forces on artificial dentures be essentially vertical. We have already said that horizontal component forces on natural teeth become increasingly destructive with the weakening of the alveolar support. In the case of artificial dentures this matter is of even greater importance. The way we can assure more nearly vertical force on the alveolar support is to make the working occlusal surfaces more nearly horizontal. This is another way of saying that the working occlusal surfaces of artificial teeth should lie essentially on a horizontal plane. It means that the teeth should be essentially cuspless.

Another mechanical requirement for artificial dentures is that the teeth cause leverage of the third order or sugar-tong variety to maintain stability of the dentures under vertical closing force. The way we can assure this favorable kind of leverage is to place the working occlusal surfaces lingually of the alveolar ridge crests. Placing these surfaces to the lingual side instead of just over or outside the crest not only operates to prevent side-to-side teetering of the dentures, but also distributes the load more evenly on right and left sides of the mouth.

Still another requirement is that the occlusal load be placed near the anteroposterior center of the denture foundation to prevent anteroposterior teetering. We can accomplish this by leaving out of occlusion all of the teeth overlying the anterior and posterior extremes of the denture foundation. This is another way of saying that we should place the occlusal load on the working occlusal surfaces of first molars and perhaps also the bicuspids.

Because of the different anchorage in natural and artificial dentures, it is not suggested that the orthodontist and the periodontist should align and form the occlusal surfaces of natural teeth according to the prosthetic plan here advocated for complete artificial dentures. It is suggested, however, that the very differences in the two situations throw in sharper relief the essential principle that both natural and artificial teeth need to be formed and placed according to the nature of their support. The orthodontist who can think and act in terms of the periodontist and prosthodontist can best serve his patients. Likewise with the other specialists.

In this discussion emphasis has been placed on the working occlusal surfaces. The other surfaces are also important. These as well as the role of jaw relation are dealt with in a recent book by your essayist, *Principles and Technics for Complete Denture Construction,* and will not be elaborated here.

## CONCLUSION

In spite of some differences in the manner of applying principles in the several specialties of dentistry, these principles themselves are the same. The mechanical principles involved in the field of occlusion should be understood and agreed on by all dentists, and the devices and techniques used in one specialty should be known in the others. Especially should the workers in orthodontics, periodontics, and prosthodontics pool their experiences and harmonize their procedures so that fewer of our patients need go down the "dontic" road of ortho, perio, exo, prostho, and more prostho. A better understanding of dental occlusion in its various phases will equip us to give our patients of all ages a higher degree of professional service.

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# EXPERIMENTS IN OCCLUSION

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THEORIES should be subjected to experiments in order to test their validity. Physicists do this continually, and thereby they have made physics one of the most dependable and satisfying of sciences.

Now much that has been proved in physics can be accepted by the denture prosthetist almost without special experiments in the mouths of patients. And yet actual clinical experiments in the mouths of patients are valuable for the purpose of discovering the special applications of physical laws to dental occlusion.

It is obvious that some occlusal forms are better than others. In full denture restoration there are a few guiding principles, conformity to which will produce chewing surfaces which are more efficient in use, more comfortable to the user, and above all less destructive to the supporting structures. The common experience that certain occlusal schemes are less destructive than others lends force to the claim that denture workers must experiment in order to develop a scheme respecting occlusal forms and placement of these occlusal forms which will be at least superior to any scheme based on assumption.

As a basis for experimentation, the dentist might well set down a few statements paralleling some of the axioms of physics. A physicist-dentist might say: "We hold these truths to be self evident:

1. "The smaller the area of occlusal surface acting on food, the less will be the force required to crush the food and the less pressure will result on the supporting tissues.

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*Comments by the Author.*—When this paper was read in 1939, there was a period of much theoretical discussion regarding the mechanical effects of various occlusal forms. Since the conflicting claims were causing confusion, the writer believed that some of this confusion could be dispelled by the simple expedient of making practical experiments.

Several members of the audience requested copies of the paper, but it is not known how many listeners actually made any experiments such as those suggested.

Again we are in a period of increased interest in new occlusal designs. The wide variety of these forms and the claims of their designers would suggest that this heretofore unpublished paper might be of some general interest. If the axioms are accepted, there can be no disagreement on the conclusions because none are drawn. The experiments are so set up that the experimenter can draw his own conclusions.

To answer the criticism that a scientific paper should contain some definite conclusions, the writer has now in preparation two essays.

One is entitled "Thirty Years of Nonanatomic Teeth." This is largely a chronological listing of the entire range of nonanatomic teeth that have been marketed (and some that have not) with illustrations and explanations of their essential features. It is proving a difficult task to get complete data from some of the sponsors.

The other new essay is entitled "Specifications for Artificial Posterior Teeth." The three papers are related.

Quite naturally the writer's convictions will be reflected, especially in the discussion of specifications. At the same time the effort is being made to present the matter objectively and in such manner that it will help the reader to gain a comprehensive grasp of the subject.

2. "Vertical force applied to an inclined occlusal surface causes nonvertical force on the denture base.
3. "Vertical force applied to an inclined supporting tissue surface causes nonvertical force on the denture base.
4. "Vertical force applied to a denture base supported by yielding tissue results in teetering of the base when the force is centralized imperfectly. The more nearly a load is applied to the center of the foundation, the better will it be supported. (A load applied equally at opposite extremes to a rigid body is the same in effect as the same load applied at a point halfway between the extremes.)
5. "Vertical force applied outside the ridge crests tends to teeter the denture bases."

In light of these axioms it is not difficult for the investigator to make some sample tests in the mouths of his patients for the purpose of learning to what extent it is practical to apply the principles of physics.

Experiments can be made with ordinary dentures of a moderate degree of jaw separation and already in service as well as on dentures especially constructed to test certain phases of engineering practice. Often comparisons can be made between two schemes by treating the right and left sides differently or by applying a principle to upper or lower teeth only. On completed dentures, the right or left side may be altered leaving the other side as a control. Some of the experiments having relation to the five axioms listed will be suggested.

Although certain portions of the posterior teeth are designed for esthetics or for other nonocclusal purposes, in the present discussion we will give chief consideration to the working occlusal areas. In the experiments suggested, when ordinary full denture restorations are mentioned, it is assumed that they were made to centric occlusion associated with centric jaw relation, that they were made with the usual sixteen so-called anatomic teeth, and that at the time of the experiment they have been worn by the patient and have proved to be fairly serviceable.

### EXPERIMENT 1, AXIOM 1

Take an ordinary full denture restoration. Narrow the upper or lower posterior teeth of one side, reducing the buccolingual area by one-half. Equal reduction is made on the buccal and lingual sides. After a few days of use by the patient, treat the other side similarly.

### EXPERIMENT 2, AXIOMS 1 AND 4

Take an ordinary full denture restoration. Remove the upper second molar of the right side. After a test period, do the same thing to the left side.

### EXPERIMENT 3, AXIOM 2

Take an ordinary full denture restoration. Mount it on an anatomic articulator. Grind the tops of all lower cusps so that the platforms thus produced lie

parallel with the lower alveolar ridge. This topping of the cusps need not eliminate them entirely, but it should extend to a level slightly more than halfway down the mesial slope of each cusp. Next, top the upper cusps so that the platforms thus produced will lie against the lower platforms. The extent of this topping should be just sufficient to eliminate the mesh of opposing cusps. Complete the occlusal adjustment with interposed abrasive paste until protrusive and lateral paths are followed smoothly.

### EXPERIMENT 4, AXIOM 2

This experiment is only for lateral shift of the bases. Take an ordinary full denture restoration and mount it on an anatomic articulator. Grind the upper buccal cusps and the lower lingual cusps so that their surfaces are horizontal buccolingually. Reduce the upper lingual cusps sufficiently to produce lateral balance. Complete the occlusal adjustment with interposed abrasive paste until lateral paths are followed smoothly.

### EXPERIMENT 5, AXIOMS 3 AND 4

Take an ordinary full denture restoration treated as in experiment 3 or 4. On the right side remove the upper second molar. If any surfaces of the upper teeth occlude with lower teeth overlying the ridge crest which presents an inclined supporting surface as seen from the buccal side, grind away these tooth surfaces. On the left side leave the second molars in contact.

### EXPERIMENT 6, AXIOMS 3 AND 4

Attach an ordinary pencil eraser to a right-angled explorer and cause the patient to bite at the mesial and distal extremes as well as at intermediate points on the posterior teeth.

### EXPERIMENT 7, AXIOMS 4 AND 5

Attach an ordinary pencil eraser to a straight explorer, the axis of the explorer and that of the eraser coinciding. Fix a narrow stiff metal strip to a lower denture base buccolingually in the first molar region and a similar one directly over it to the upper denture or denture base. The strips should extend well buccal to the ridge crests. Cause the patient to bite at a point midway between the right and left ridge crests, at points buccal to the ridge crests, and at intermediate points.

### EXPERIMENT 8, AXIOMS 4 AND 5

Take an ordinary full denture restoration treated as in experiment 3. With a knife-edge mounted wheel, cut grooves along the posterior teeth in such manner that the lower grooves lie directly over the lower ridge crest and the upper grooves lie directly under the upper ridge crest. Now grind down all of the lower tooth substance buccal to the lower right groove so that the buccal portions of the lower right teeth all lie 1 mm. or more below the opposing upper teeth in occlusion. After a test period, do the same to the left side.

### EXPERIMENT 9, AXIOMS 4 AND 5

Take the dentures as treated in experiment 8. Cup out the upper tooth substance of the right side between the grooves and the buccal cusps. This will produce a rounded mesiodistal trough which should be about 1 mm. deep. After a test period, do the same to the left side.

### EXPERIMENT 10, AXIOM 2

Open the jaw relation until the opposing ridge crests diverge markedly toward the anterior part. Construct dentures with a cuspless occlusal plane parallel with the lower ridge crest as seen from the buccal side. Test under biting pressure for anterior pressure on upper and lower bases. Change the occlusal plane so that it is parallel with the upper ridge crest and test again.

These are all simple mechanical tests, ranging from those in which the demonstrations are not at once clear in all cases to others in which the demonstrations are both instantaneous and almost spectacular. Of course many other and more elaborate tests might be made to demonstrate the action of mechanical principles in the patient's mouth, but the experiments suggested are sufficient in scope and number to point clearly to the necessity for suitable tooth forms and for compliance with the dictates of good engineering in artificial denture restorations.

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# BASIC PRINCIPLES IN IMPRESSION MAKING

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MY objective in this presentation is to bring to your attention considerations that appear to me to be basic and fundamental in making impressions—impressions of mouth tissues for the purpose of constructing mucosa-attached artificial dentures.

Someone has said that "you can't learn dentistry from books." This is true, and it is likewise true that you cannot learn dentistry without books, without theories and hypotheses deduced from basic principles, for problems can be better solved in practice when they are first resolved in theory.

## RESOLUTION OF THE PROBLEM

Let us now resolve the impression problem—trace its factors to their very roots. The impression problem would not be a problem if we were taking impressions of casts. The problem is due to the fact that the mouth is lined with displaceable tissue; displaceable tissue that varies in degree of displaceability, according to: (1) its thickness, (2) its rigidity, (3) the point, magnitude, and direction of the forces applied to it. In view of these facts, it is reasonable to say that the ideal impression must be in the mind of the dentist before it is in his hand. He must literally make the impression rather than take it. The kind of an impression he will make depends on many factors, factors which we shall presently consider.

## DEFINITION OF IMPRESSIONS

An impression is a registration of mouth tissues made with an impression material. It is a record, a facsimile of mouth tissues taken at unstrained rest position or in various positions of displacement. The impression form is the shape of the saddle which will harness mouth tissues for the purpose of counteracting masticatory forces delivered at different levels of jaw separation. The mucosal displacement recorded in an impression will vary in degree and direction. Unless an impression is made with the mucosa in an unstrained rest position, it is well nigh impossible to duplicate. It is hardly likely that two impressions taken of an edentulous mouth are ever identical. For in seating the impression tray containing the impression material, the amount of force, the direction of the force, and the point of application of the force will vary with each attempt.

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Until an impression material is developed that may be sprayed with light and uniform pressure upon the mucosa, registrations in rest position will represent an ideal rather than a reality.

The present practical means at our command merely approach this ideal without ever attaining it, and considering the variables incident to denture construction, it is fortunate that this is so. For, unless mucosal rest impressions are combined with certain stabilizing factors, they may be inadequate to effect sufficient retention during function. Then again the construction of dentures from tissue-at-rest impressions limits the choice of denture base materials to those requiring a more exacting technique, usually metal castings of the impression area. The impression surface must be so meticulously reproduced in the finished denture that many denture base materials due to their curing shrinkage and the use of separating media cannot be employed.

## THE IMPRESSION AREA

For purposes of our present analysis let us somewhat arbitrarily divide the impression area into two parts: (1) the vault-ridge areas, (2) the flange-heel areas. I cannot imagine a situation where it is undesirable to achieve unstrained rest tissue registration in ridge-vault areas. However, I have encountered many cases where rest registration of flange-heel areas would not suffice to retain the denture during mastication. It is important that this differentiation be clear in one's mind. Rest registrations are apt to result in insufficient saddle and flange areas resembling old-time plaster impression dentures where lowers especially were flangeless. And, ever since Dr. Wilfred Fish's pronouncement of the importance of flange inclines in stability, one is loathe to permit this stabilizing force to go unemployed.

## THE THEORY OF REST IMPRESSIONS

The facts cited in support of the theory of rest impressions are irrefutable. However, the interpretation of these facts and their unqualified application in practice may be questioned. The facts are these: (1) The laws of hydrostatics tell us that water is incompressible, i.e., you cannot take a given amount of water and through pressure reduce its volume. (2) The mucoperiosteum is a semisolid with over 80 per cent of water in its composition, and if the known facts of hydrostatics are utilized, the mucosa is incompressible by any force that the muscles of mastication are able to deliver. (3) While the mucoperiosteum cannot be compressed, it may, however, be displaced in the absence of confining walls. (4) Any substance, no matter how fluid, when enclosed in a rigid container, takes on the same rigidity as that container. Thus, soft tissue, provided it is completely contained, would under these circumstances become as rigid as bone. (5) Tissue is elastic and will not remain passive in a displaced position. It will try to recover its unstrained rest form.

### MOVEMENTS OF THE MUCOSA

It is possible with rest impressions to harness the mucoperiosteum to such an extent that within the area covered by the impression it cannot be appreciably moved by a vertical force applied within the ridge crest; but this is not true when the vertical force is applied outside the limits of the base area. The mucosa, likewise, is displaced when the force applied is horizontal or possesses a component that is horizontal, this, regardless of where it is applied, within or without the base area. Under these circumstances, the mucosa may not move within the impression, but one would have no difficulty in having it move with the impression. As I cautioned, we must be careful about the interpretation of so-called mucostatic facts, for all one has to do to verify my contention is to grasp a rest impression in the premolar region with index finger and thumb and press sidewise or forward and backward. One would have no difficulty in detecting movement. Let me repeat for emphasis. When the tissues are completely contacted (whether at rest or in positions of displacement is immaterial), they are impotent to move within the impression; no room for movement will be available.

### CONTACTING DENTURE SURFACE

This fact accounts for the lack of mucosal irritation in the presence of the rough contacting surface found with mucostatic dentures. It is fallacious to argue, as some do, that minute tissue registration in an impression will result in multiple miniature wedges that irritate the mucosa unbeknown to the patient because it is below the threshold of pain response. A wedge cannot operate except in space, for a wedge is an incline plane moving under an object. When the tissues are completely contacted, wedging action cannot take place. There is no room available for movement. It appears evident that minute registration of soft tissues in a state of rest is not objectionable on the ground that it results in a rough surface. It is also wise to bear in mind that a relatively rough surface increases the surface area in contact with the mucosa; and this increases the forces of interfacial surface tension, which is directly proportional to the area involved. In arguing this point, the shoe analogy is sometimes cited; that is, what would happen to the sole of one's foot if the contacting shoe surface was a minute reproduction of tissue form? The analogy, however, is ill chosen, for conditions are not similar. The foot rests in the shoe, whereas a well-constructed denture is attached to the mucosa.

### THEORY AND PRACTICE

Someone has said: "When theory and practice differ, use your horse sense." This is good counsel in our impression problem. In theory, rest impressions are plausible, but in practice, they may not suffice for retention and function. However, they are ideal during periods of rest which embrace the greater part of the day and night. But under the hazards of a resistive bolus (where one-sided horizontal forces prevail) such impressions may be dislodged or rather dentures made from such impressions may be dislodged. Yet, this must be said in favor of rest impressions: Given a satisfactory end result, dentures made from rest

impressions will remain serviceable for a longer period of time than dentures built from impressions taken during displacement. For displacement will subject osseous tissue to a continuous stress. Displaced mucosa has a steady urge to return to rest position. Then, again, displacement results in tensile and shear forces to osseous tissue. Just as intermittent stress, rather than continuous stress, is more physiologic to bone, likewise, bone is more counteractive to compressive loads than to tensile and shear stresses.

### RETENTION AND STABILITY

It is well in our thinking to be clear about the terms *retention* and *stability*. Generally speaking, stability is that state wherein forces that tend to cause motion are successfully resisted without a loss of equilibrium. A stable denture is one that successfully resists the magnitude and direction of functional forces that tend to alter the positional relationship of the denture to its osseous support. Probably it should be stated that a stable denture is one relatively stable, for absolute stability under edentulous circumstances is out of the question. In this definition of a stable denture, it is important to note that the term osseous support and not mucosa was used. For, during function, a denture may lose stability and yet maintain its positional relationship to the mucosa. Under these circumstances this denture still possesses retention. Thus, retention may be defined as that state of a denture wherein functional forces are unable to destroy the attachment existing between the denture and the mucoperiosteum. It is thus apparent that a denture may be unstable and yet possess sufficient retention to resist dislodgement. As long as the denture does not lose its grip upon the mucosa under functional loads, it may be said to possess an adequate degree of retention. Stability is something else. If a denture does not move noticeably in function, it is said to be stabilized. Movement means displacement of the mucoperiosteum in function.

### RELATION OF DENTURE TO MUCOSA

It is probably a misstatement to say that a denture merely rests on the mucosa, for the statement suggests that its relationship to its base is that of a chair to the floor or a dinner plate to a table. This is not the case. A present-day denture does not merely rest upon its mucosal base; it is attached to it, as veritably as the mucosa is attached to the underlying bone. The difference is that in one case the attachment is fixed and in the other it is not fixed. That is, a denture can be detached, although I heard not too long ago of a lower denture that stuck so tight to the lower jaw that the patient was unable to remove it and the dentist had to give two mandibular injections in order to loosen it. That, of course, is an unusual case. Ordinarily, the lower denture surely can be detached and often is when we don't want it to be. When an object is attached to a base, the base may be employed to support or suspend the object. The dead weight of the lower denture is supported by the lower base. The dead weight of the upper is held in suspension by the upper base. When the force is directed toward the base, the base is used to support the object. When the force is directed away from the

base, the base is used to suspend the object. A base, to support an object, must be hard and unyielding, possessing compressive strength. A base, from which to suspend an object must be tough, possessing tensile strength.

### STRATEGY OF USING SOFT TISSUE

Our strategy should be to use mouth tissues to support the denture rather than to hold the denture by suspension. Only in the event that this is not possible should the denture be suspended from mouth tissues. If the plan is one of suspension, then the soft border tissues are useful. A denture may be supported, suspended, or sustained by the mucosal base in one of three ways: (1) A denture is supported when the force is basewise and perpendicular, resulting in compressive loads. (2) A denture is suspended when the force is counterbasewise, resulting in tensile loads. (3) A denture is sustained when the force is basewise in one area and simultaneously counterbasewise in another area. This results in compressive, tensile, and shear stresses. To reiterate, it is more descriptive of the situation to say that a denture is attached to the mucosa than to say that the denture rests on the mucosa.

### MEANS OF ATTACHMENT

What are the means of attaching a denture to the mucoperiosteum? The means are the forces of: (1) interfacial surface tension, (2) atmospheric pressure, (3) a combination of both. By means of the interposed salivary film, a denture is attached to the mucosa, as two pieces of moistened glass would be attached, through interfacial surface tension. By means of rarified air spaces between the denture and the mucosa, a denture is attached to the mucosa, as a suction cup is attached to a windshield of a car, through the force of atmospheric pressure. Carrying a large deep air chamber in the middle of the hard palate, a well-adapted denture is attached to the mucosa through both the forces of surface tension and atmospheric pressure.

In function, atmospheric pressure is superior to interfacial surface tension as a retentive force, for forces horizontal as well as parallel to the mean mucosal plane are resisted. Interfacial surface tension will resist only forces perpendicular to the axes of surface tension forces.

### ATMOSPHERIC PRESSURE—SURFACE TENSION

And yet I would not recommend the use of atmospheric pressure to secure attachment. These are my reasons: (1) Attachment through atmospheric pressure is usually transient, for air chambers and reliefs tend to fill in with tissue or saliva. This is understandable when one considers the mucous glands that line the palate and the possibility of moisture seepage. The continued existence of rarified air spaces is precarious under these circumstances. (2) The resistance to detachment by horizontal forces that vacuum chambers and reliefs provide may

not prove physiologic to alveolar bone. Forces parallel to the mean mucosal plane will always result in displacing the mucosa, even though the denture is not detached.

### MUCOSA CONTACTED BUT NOT CONTAINED

It is well to keep in mind that mouth tissues including the mucosa may be contacted, but it can hardly be said that they can be contained. A denture cannot act as a container for mouth tissues in the same sense that a hypodermic syringe acts as a container for the anesthetic solution.

If a denture could contain soft tissue as a syringe contains the solution, then this would be the solution of the full denture problem. For then Pascal's laws would apply—namely, (1) that any substance, no matter how fluid when enclosed in a rigid container, takes on the same rigidity as that container, and (2) that pressure applied to a confined liquid is transmitted undiminished to all parts and acts in all directions. If tissues could be contained as well as contacted, then all our program of preventive prosthetics, where we endeavor to salvage as much alveolar bone as possible, would be a waste of time. For, if a denture could serve as a true container of mouth tissues, then it would follow that soft tissue would be as good as bone in stabilizing a denture. And every practitioner knows from bitter experience that this is not so.

### MUCOSTATIC SCHOOL

Let me again say that no one can quarrel with the facts cited by the mucostatic school of thought. It is the application and interpretation of these facts that we wish to question. In my opinion, Mr. Harry Page[1] and those associated with him have rendered a valuable service to prosthetic dentistry in their provocative announcements. It is natural for anyone who has discovered an important truth to conclude that it is all the truth there is. The crux of Page's announcement is this: Soft tissue should be registered in an impression in unstrained rest position—any other position will compel tissue to try to regain its rest position—this leads to dislodgement of the denture. He does not seem to comprehend that there are forces that can displace the mucosa without disturbing tissue contact with a denture. A denture may move with the mucosa without being detached from it.

Free movements of tissue are limited by two factors: (1) its thickness, (2) its rigidity. Thickness and rigidity are in a state of constant flux depending on fluid content and the stresses applied to tissue. The mucostatic school argues that soft tissue has permanent shape. This is a half-truth. It has a definite shape at any given time and when distorted will attempt to regain it. But this shape is not permanent—tomorrow it may have a different shape.

Mucostatics contends that all tissue acquires rigidity of form when completely contacted. This would be true if mucosa had no thickness which, of course, is

inconceivable. As long as the mucosa has thickness, its rigidity of form is conditioned by other factors than complete contact with the denture base. It is conditioned by the point, magnitude, and direction of masticatory forces applied to it.

## ALVEOLAR BONE

Mucostatics has little to say about bone—it concentrates upon soft tissue. It is interesting to me because my emphasis has been alveolar bone and its preservation. We have maintained that the primary prosthetic problem is the preservation of alveolar bone. Preserve alveolar bone, and the soft tissues will take care of themseles. Whether a denture is suspended from the mucosa or supported by it is important and not irrelevant as Page contends. This relevancy concerns itself with this fact—all bone and especially cancellated alevolar bone is more resistive to compressive loads than to tensile and shear loads.

After mucosal displacement, a strained equilibrium is established, and alveolar bone is subjected to tensile and shear stresses. In the human skeleton, Nature provides us with no instances where a mass of cancellated bone is used for any other purpose than that of resisting compressive forces. This thought is discussed at length in a published manuscript.[2]

## FORCES OF RETENTION

Retention begins with the impression. It depends primarily on the forces that produce attachment of the denture to the mucosa. These forces include adhesion, cohesion, and surface tension. Mucostatics dismisses adhesion and cohesion as factors in retention, the entire phenomenon being attributed to interfacial surface tension. An analysis of the problem would prove beyond doubt that if it were not for the forces of adhesion, the sticking together of unlike molecules, and cohesion, the sticking together of like molecules, the force of interfacial surface tension would not exist. For example, if you cannot wet a surface, which means that molecules of $H_2O$ will not adhere to the molecules composing the surface, then surface tension is out of the question. Attachment of a denture to the mucosa is possible because both tissue and denture base materials can become wet, which means that its molecules will adhere to $H_2O$ molecules. For example, two pieces of glass will not stick together if instead of moisture, mercury is placed between them. The reason is that the mercury molecule is not adhesive to glass. Likewise, if it were not for the force of cohesion, the interposed salivary film could manifest no adhesion. For, if like molecules did not stick together, then they could not exist in sufficient mass to stick to anything else.

My interpretation of retention is that, as a rule, it is not due to atmospheric pressure, even though a peripheral seal and roll may enhance it. Atmospheric pressure plays a roll in retention only when a vacuum chamber or a relief is present and the vacuum chamber or the relief is not filled with tissue or saliva. When the denture moves under masticatory loads, the function of border tissue and roll is to enable the border tissues to follow the movement and thus keep out saliva, as well as air. If adhesion fails, that is, if the denture is detached

and dislodged, it is probably due to extreme torque and failure of the border tissues to maintain contact. In the presence of mucosal torque, a relief in the palatal area will help retention. Palatal relief prevents the vault from acting as a fulcrum and permits the denture to shift bodily, the movement being more translatory than rotary. Rotation puts more strain on retention than translation. As far as retaining a denture is concerned, it is more advantageous to permit the denture to shift bodily than to set up a lever action. When the denture shifts bodily, that is, shifts horizontally, the cheek on the working side comes to the rescue and helps to stop the movement. But if the denture moved vertically with the teeth apart, there would be nothing but retentive forces to rescue the denture, nothing to resist the movement. Under that circumstance, there would be a greater movement of the denture and consequently a greater need of the border tissues to follow the movement.

## FACTORS IN STABILITY

Stability begins with the impression, by the avoidance of noticeable displacement in ridge-vault areas. The impression, however, is a minor factor in the problem of stabilizing a denture. The important problems are the following: (1) the inclination of the flanges, (2) the form, size, and arrangement of the posterior teeth, (3) the position of the posterior teeth in relationship to the foundational center, (4) the form of the polished palatal surface. In fact I deem these factors, which lead to a stabilized denture, so important that it is a rule with us never to take constructional impressions until these factors have been determined in advance. This information is established through diagnostic impressions and diagnostic denture models. During function, if the above-mentioned factors result in an essentially vertical seating force, then impression registration with the mouth tissues reasonably at rest is in order. We then endeavor in the constructional impressions to minimize tissue displacement in heel-flange areas as well as in ridge-vault areas. Post damming and high thick flanges with peripheral seal are avoided.

If we must, for one reason or another, compromise with the factors that lead to stability, then we know that mucosal displacement during function is inevitable. We ought then to be concerned with retentive forces that will rescue the denture from dislodgement during use. Under these circumstances, the impression should register some degree of displacement, especially at the borders. This will result in: (1) higher and thicker flanges, (2) snugger borders including an effective post dam. This will eventuate in a peripheral seal which will better prevent dislodgement. However, it should be recognized that function under these circumstances is inimicable to alveolar bone preservation. Bone atrophy necessitating periodic refitting and rebasing of the denture is to be expected.

## PREVENTIVE PROSTHETICS

A program of preventive prosthetics must commence with rest registrations of ridge-vault areas. Impressions containing such registrations must be com-

bined with occlusal working units so shaped and placed that the resultant flange inclinations will help seat the dentures during function. In fact, it may be said that the prime requisite of artificial teeth is to help support the denture. For only when dentures are supported and seated in function will the teeth be able to prepare food physiologically.

### IMPRESSIONS ONLY ONE PHASE OF PROBLEM

This approach to the subject of impressions makes obvious the inadequacy of dealing with the impression problem as though it were a separate entity. A rest impression merely assures an absence of tissue displacement during rest periods when neither teeth, tongue, lips, nor cheeks are forcefully contacting the dentures. This is important, for rest periods are prolonged periods. However, we should be clear in our prosthetic thinking. During function, rest registrations are impotent to prevent tissue displacement by horizontal forces. To reiterate for emphasis, it is not a question of the mucosa within the denture outline being displaced, but rather of the entire mucosal mass moving laterally and antero-posteriorly.

In the presence of inclines of both form and arrangement, there will be a horizontal component parallel to the base plane and thus capable of displacing the mucosa *en masse*. To prove this point, grasp any denture between thumb and index finger, press it back and forth and from side to side. You will experience no difficulty in moving the denture regardless of how the impressions were taken.

### A MATHEMATICAL APPROACH

Rest registration of ridge areas is important in attaining stability, but to conclude as some do that this is all there is to the quest of stabilizing a denture is, to say the least, an oversimplification. In fact, horizontal stability is impossible in the presence of horizontal forces. This becomes clear as one considers the nature of the denture seat in the light of Synge's mathematical analysis.[8] Synge, a mathematician, working with Dr. Box of Toronto, has advanced a theory that explains tooth mobility better than any other theory yet conceived.

According to Synge, the increase in displaceability of an incompressible membrane placed between two rigid bodies is directly proportional to the cube of the increase in thickness, or to the cube of the decrease in rigidity. His calculations were concerned with the periodontal membrane and tooth mobility. Yet there appears no reason why his conclusions are not equally applicable to account for mucosal displaceability in the presence of horizontal forces.

### COMMENTS ON NATURAL AND ARTIFICIAL DENTURES

There is greater similarity than we commonly suppose between natural and artificial dentures. Both are attached to bone, one by means of the periodontal membrane, the other by means of the mucoperiosteum. The presence of roots with the natural denture, the absence of roots in the artificial denture is not

their essential difference. The backbone of their difference is the difference between the periodontal membrane and the mucoperiosteum—their difference in thickness and rigidity. The crux of the entire problem lies in the fact that the periodontal membrane can resist displacement much more readily than the mucoperiosteum. A conservative estimate is that the natural organ is 216 times as resistive to displacement as the artificial. If we arbitrarily assume the mean thickness of the edentulous mucosa to be five times that of the periodontal membrane and its rigidity to be one-half, it will follow that 1/216th part of the force required to displace a natural tooth will displace an artificial denture. That is, the stabilizing capacity of the mucoperiosteum in the presence of a horizontal stress component is only 1/216th part of the stabilizing capacity of the periodontal membrane. This figure is really an understatement. Even at that, the differential is enormous.

## TISSUE REGISTRATION

A registration other than at rest should be for purposes of expediency only, for alveolar bone is best preserved with rest registrations. But, in the everyday practice of prosthetics, many cases will present themselves where rest registrations will not suffice to effect retention and comfort during chewing. It may be necessary to register in the impression a certain degree and direction of tissue displacement, this, in anticipation of dislodging forces during function.

Rest registrations in the impression must be combined with flange and tooth forms and placement that result in compressive loads. Otherwise the degree of mucosal displacement will be too great and denture dislodgement imminent.

## CONCLUSION

In conclusion, let me say that the importance of the impression phase has been overemphasized. Steps essential for retention have been played up while the forces that lead to stability have not received the emphasis that they merit.

## REFERENCES

1. Page, Harry: From a manuscript of a summary of the paper read at the 43rd annual session of the South California Dental Society of Los Angeles, January, 1940.
2. DeVan, M. M.: An Analysis of Stress Counteraction on the Part of Alveolar Bone, with a View to Its Preservation, D. Cosmos **77**:109, 1935.
3. Synge, J. L.: Phil. Tr. Roy. Soc. Lond., Series A, 231.
4. Gabel, A. B.: D. Cosmos **76**:677, 1934.

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# EYES IN YOUR FINGERS

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*(. . . teach me what I am blind to . . . Job 34:32 [Moffatt])*

THE lingual flanges of full lower dentures have been the subject of many opinions. Most are derived from what the eye can see, what the imagination can surmise, and what the adjacent muscles with their associated structures can mold into an impression.

Many are the techniques for delineating the lower denture shape and border, but it was a patient who unconsciously taught me the value of what is about to be described.

This person, a man in his late 50's, objected strenuously to the liberal posterior throat form extensions, with their beautifully rounded edges, that he found on a new lower denture I had proudly made for him. He had the effrontery to demand that they be cut off. He even claimed that they got in the way of his tongue and that sometimes his tongue caught under the edge causing the supposedly stable denture to become embarrassingly acrobatic.

What he wanted was preposterously contrary to every thing I had been taught, but to humor him I poked an index finger down where he pointed to see if I could feel what he claimed to feel. Then came the dawn. Mr. Patient was right. My finger tip found a massive overhang protruding beyond each mylohyoid ridge. These projections occupied space he needed for his tongue. They had a broad undersurface for the sides of his tongue to pry beneath. They stood away from the internal surface of his mandible because they had been formed to clear the functioning mylohyoid muscle.

Now that the logic of Mr. Patient's complaint was clear, I attempted to make the junction between the lingual border of the denture and the surface of the mandible feel as smooth to my finger tip as he wanted it to feel to his tongue. I found that with repeated feeling, trimming, and feeling, the denture border eventually became congruent with the outline of the mylohyoid ridges. The thickness over these areas was reduced to practically nothing. Analysis of what seemed to be wreckage showed no loss of stress-bearing surface. It also revealed no significant difference in the sealing contact left to prevent the entrance of air. Neither was there any change in stability or adhesion.

Study also showed that no change had been made in any lingual border outline anterior to the two first molars. There did remain a small rounded projection at the most distal portion of each lingual flange where the denture base curled over the lingual aspect of the retromolar pads. This seemed to be an important sealing point.

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In other words, the entire lower denture outline remained as it was formed originally by muscle trimming except where it engaged the mylohyoid ridge, and the change had been confined to removing material that added nothing to pressure-bearing capacity. On the positive side, there no longer existed abnormal

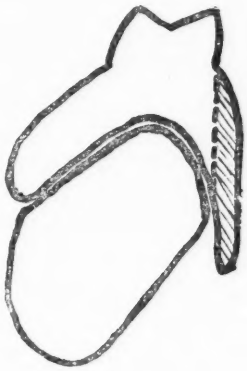

Fig. 1.

Fig. 2.

Fig. 1.—The shaded area represents the mylohyoid portion of a conventional lingual flange which is removed after "looking with the finger tip." Note how tongue room is gained, overhangs are removed, and how the new border of the denture blends into the mylohyoid ridge.

Fig. 2.—In the cuspid and bicuspid area, tongue room is gained by continuing the new vertical face of the molar area on forward in this manner. The margin is left thick and deep in the floor of the mouth to maintain a seal. Base material is hollowed out only as shown by the shaded area.

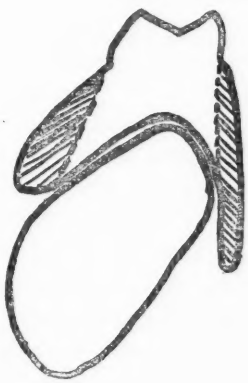

Fig. 3.

Fig. 4.

Fig. 3.—Shaded areas represent portions of a tooth-borne partial denture removed to make the margins feel smooth and continuous with the tissues. Roundness is unnecessary here because moving tissue need not rub the tooth-borne partial denture border. Maximum extension of the base for weight bearing is not needed; therefore, the borders can be both short and angular. Comfort is enhanced, and food traps are reduced.

Fig. 4.—Occasionally a bit of beveling, as indicated by the shaded area, may be necessary. When such a possibility exists, it is wise to leave the margin slightly prominent and reduce it more when adjustments in the seating area have been completed. Otherwise, there may be too little stock left to maintain an ideal extension after the beveling has been done.

encroachment on tongue space. Nor did there remain inverted catch-shelves for the lateral aspects of the tongue to lift or rub against.

When this was accomplished, Mr. Patient gave his approval, and, since he was my second-door neighbor who sometimes loaned me garden tools, he said, "You jughead, why didn't you make it like that in the first place?"

This little episode occurred about ten years ago. Since then, many lower dentures have been altered according to what is seen by the "eye in my finger." All new lower dentures have been similarly finished. For several years now it has been my practice to take a fully muscle-trimmed lower impression, build the denture to those extensions, and later finish the outline over the mylohyoid ridges in the manner just described.

The smooth principle of tissue and denture continuity has also been extended to include all borders of clasp-retained, tooth-borne partial dentures, thereby avoiding food traps around buccal margins as well as promoting smoothness on the tongue side.

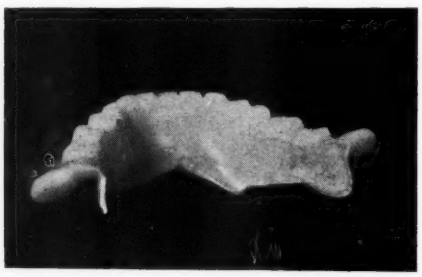

**Fig. 5.—Photograph of a practical case. The outline will vary considerably with anatomic differences from patient to patient. This is a good example of the general principle.**

In explanation it may be stated that wherever a catch can be felt by an exploring finger tip, a food trap or discomfort for the tongue will exist. When such projections, protuberances, or overhangs are removed, a corresponding increase in comfort will ensue.

There is a precaution to observe. When in doubt as to the need for relief in the stress-bearing area above the mylohyoid ridge, it may be necessary to leave a little more thickness in the denture base than finger exploration indicates. Then at a later date, when safety is assured, further thinning may be done. Also in some instances, a sharp margin may require some beveling on the ridge contact side to avoid an abrupt change of outline between pressure-bearing and non-pressure-bearing tissue areas and to eliminate soreness. A rounded denture margin is needed only where it lies firmly against, or in, a reflection of tissue, for example, in the buccal fold. When contact with the fold is light or short, no roundness is needed because the tissue does not in this case rub around the border; then greatest comfort will be assured when the denture border fades or blends as a continuation of the marginal ridge contour.

No substitute for the "eye in the finger" has been found by the author. Minute differences in amount and flow of impression material can cause sub-

stantial variations in marginal form and limits. For this reason the tip of the index finger should always "look" at the margins of every newly constructed denture so that suitable outline finishing can be completed.

Dentures which are already giving apparently satisfactory service may often be rendered more comfortable by using the same procedure. The age of the denture is no criterion as to whether or not the tongue can be given more room and freedom from protruding encumbrances. Long tolerated marginal food traps may need to be eliminated. Comfort should be judged by what may be attained, not by the degree of resignation to fate.

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# FUNDAMENTALS OF THE IMPLANT DENTURE

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THIS article will be concerned with a completely new approach to an age-old problem, namely, the replacement of teeth for the edentulous mandible. A proposed solution of the problem is the full lower implant denture. Following the basic principles established by many surgeons working with implants throughout the body (Fig. 1), we were convinced that there was a possibility of utilizing implant procedures for the retention of full lower dentures.

To mention some of the work done by these men, Venable and Stuck,[1] in July, 1938, reported: "In the 46 clinical cases which we are reporting, Vitallium appliances have been used in many different ways in bone, and it seems that this material is totally inert in human bone as we have found it to be in animal bone. Hence, we are inclined to think that it opens a field of surgery which has unlimited possibilities. With these facts bone surgeons can return with saftey to the use of metal appliances without fear that bone will not heal around them."

Secord and Breck[2] reported in July, 1940, that in attempting to remove a bone plate held with four screws, despite their combined efforts they were able to loosen only one of the four screws. The plate and screws were all left in situ. In their conclusion they stated: "We believe that until there is evidence to the contrary, these plates should be left in indefinitely."

Cameron and Henderson[3] reported in September, 1940, that in more than 100 cases in which metals were used for the fixation of fractures, Vitallium showed no evidence of irritation to the surrounding bone or soft tissue. The usual discoloration and staining seen when other metals were used was absent.

Doherty[4] reported in April, 1941, that in his opinion Vitallium was the metal most suited for orbital implantations.

Geib[5] reported in July, 1941, his extensive work with skull plate implants.

Smith-Peterson[6] reported in April, 1939, that fifteen years have elapsed since this work started and that the principle of the two-stage mold arthroplasty is sound, as was proved by the glass molds. Since these are radiotransparent, it has been possible to follow the different stages of bone repair. "The fear that the glass mould might break has restrained us as far as effective exercise is concerned. With the advent of Vitallium this restraint has been removed, and the post-operative course of events has been accelerated."

Koontz[7] reported in 1948 the use of a tantalum mesh in the repair of ventral hernias. He stated that the mesh had become covered by a thick and tough envelope of fibrous tissue and could not be separated from it. "A firmer and more thoroughgoing closure of the defect can scarcely be imagined."

Basically, the edentulous patient can be classified in one of two categories: first, those patients who can tolerate and are satisfied with conventional dentures

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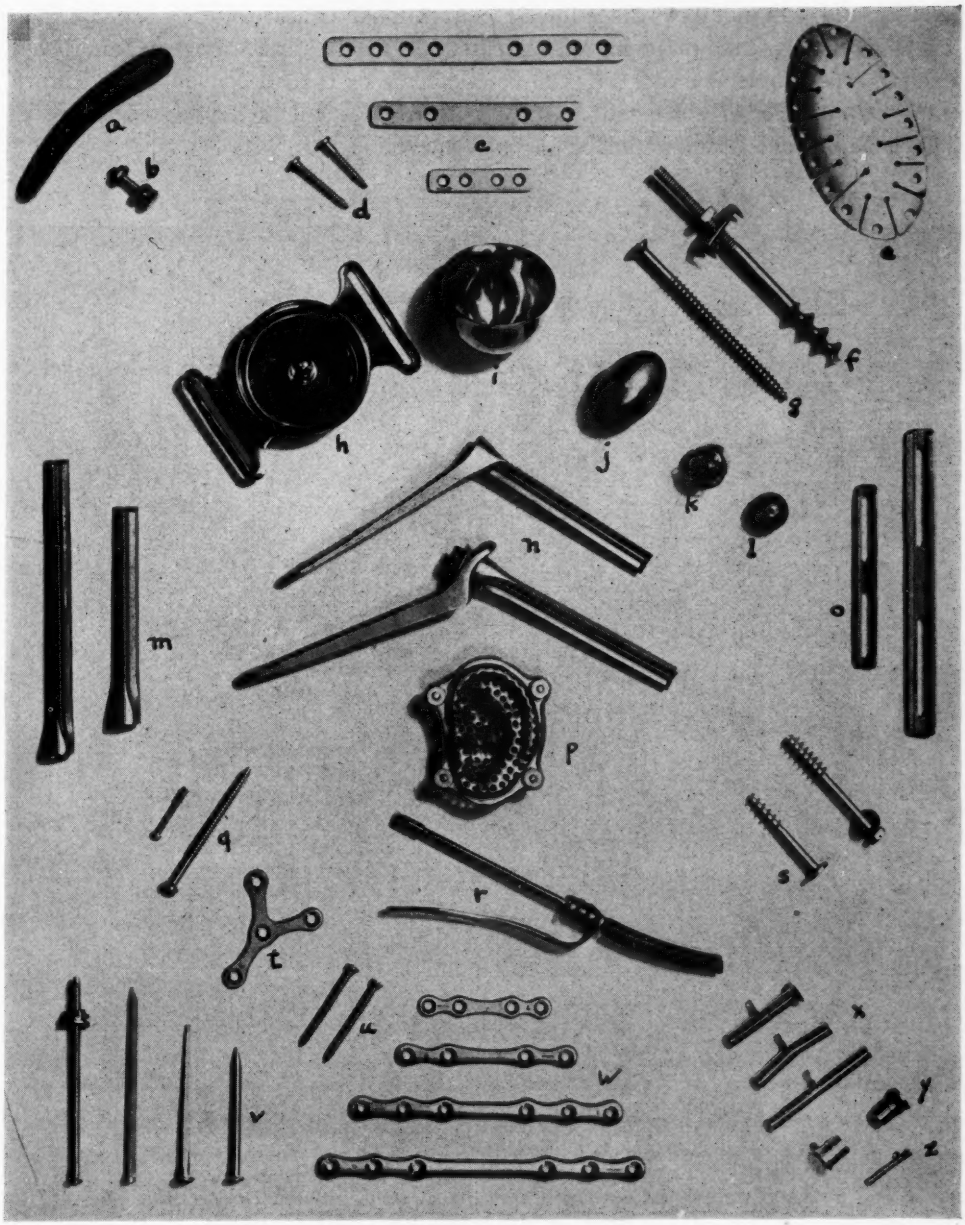


Fig. 1.—Various type implants used throughout the body. *a*, Spinal fusion plate, Wilson type; *b*, bolts, Wilson type; *c*, bone plates, Venable type; *d*, screws, Wood type; *e*, skull plate, Hoen type; *f*, hip screw, Lippman type; *g*, hip screw, Demuth type; *h*, colostomy plug, Smith type; *i*, hip cup, Smith-Petersen type; *j*, testicular implant, Bowers type; *k*, radius cap, Speed type; *l*, orbital implant, Doherty type; *m*, hip nails, Smith-Petersen type; *n*, intertrochanteric fracture appliances, Jewett type; *o*, contact splints, Eggers type; *p*, ear mold, Peer type; *q*, screws, transfixion; *r*, retention catheter, Kennedy type; *s*, lag screws, Johannson type; *t*, Y plates, Sherman type; *u*, screws, Sherman type; *v*, fracture nails; *w*, bone plates, Sherman type; *x*, bile duct tubes, Pearse type; *y*, blood vessel tubes; *z*, nasolacrimal duct tubes.

and, second, those patients who for some reason beyond our control cannot tolerate and will not be satisfied with conventional dentures.

Fortunately, the majority of patients fall in the first category, and even though some problems exist, they can be overcome by careful conventional denture construction. We are now left with the patients that fall in the second category. This group, which is well populated, is our concern.

Fig. 2. Fig. 3.

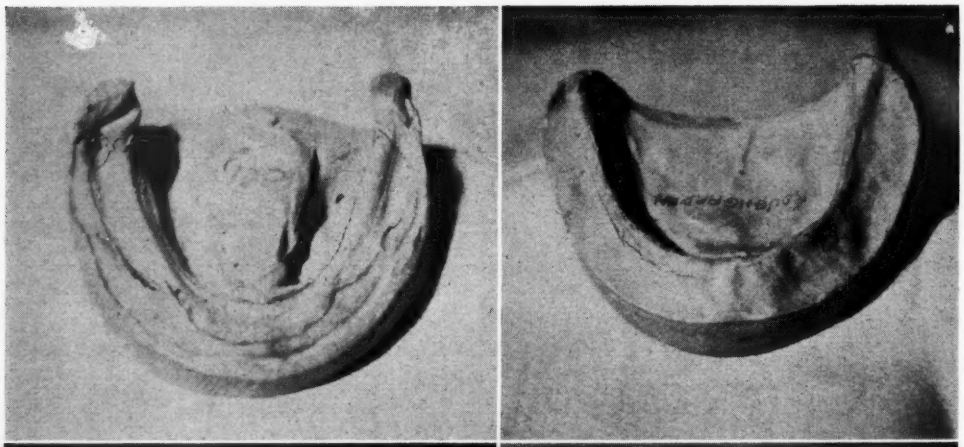

Fig. 4. Fig. 5.

Fig. 2.—Low flat ridge in anterior section level with floor of mouth.
Fig. 3.—Sharp spiny ridge continuous to retromolar pads.
Fig. 4.—Complete atrophy of mandibular ridge with anterior section below level of genial tubercles.
Fig. 5.—Low flat ridge of senile atrophy.

In order for us to solve these prosthetic problems, we have visualized what the patient was seeking most in a full denture. What is the compelling force that drives the edentulous patient to a dentist? It is the search for comfort, complete mental and physical comfort. All other objectives of these patients, such as esthetics, mastication, and prevention of further tissue damage to the mouth, are important, but they are not the primary requisites that urge them to seek

this denture service. Discomfort in the use of artificial dentures is the primary cause of failure.

Our efforts are directed to those patients who have difficulty tolerating conventional full lower dentures psychologically and to those patients whose mandibular anatomy, such as torus mandibularis, low flat ridges that approach senile atrophy

Fig. 6.

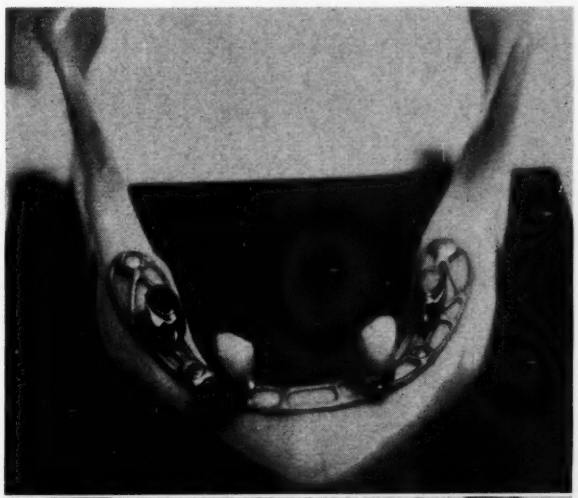

Fig. 7.

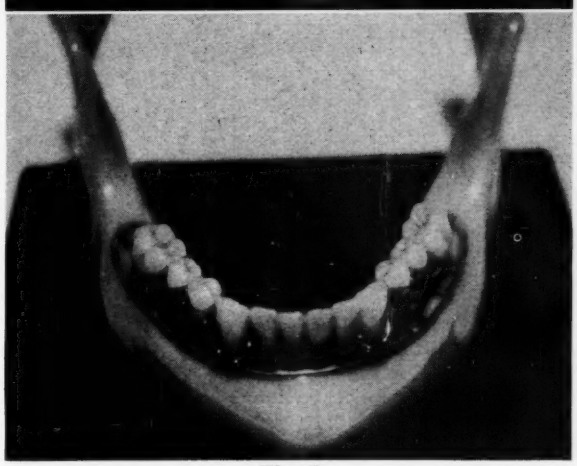

Fig. 6.—Lower Vitallium implant showing wide open meshwork to allow tissue to proliferate more readily.
Fig. 7.—Full lower implant denture seated on implant.

where invariably the mental foramina are close to, if not on top of, the ridge, sharp spiny ridges, and flabby tissues, make it impossible to construct conventional dentures successfully (Figs. 2, 3, 4, and 5). We are also concerned with restoring to function those patients having abnormal oral conditions caused by traumatic injury, surgical removal of pathology, and seventh nerve involvement.

All the known varieties of oral implants[8, 9, 10] that were previously attempted or in use up to 1947 were inadequate for our intended purpose, that is, the

retention of a full denture by means of implantation. Consequently, the implant denture was developed on an entirely different principle with most favorable results (Figs. 6 and 7).

Fig. 8.

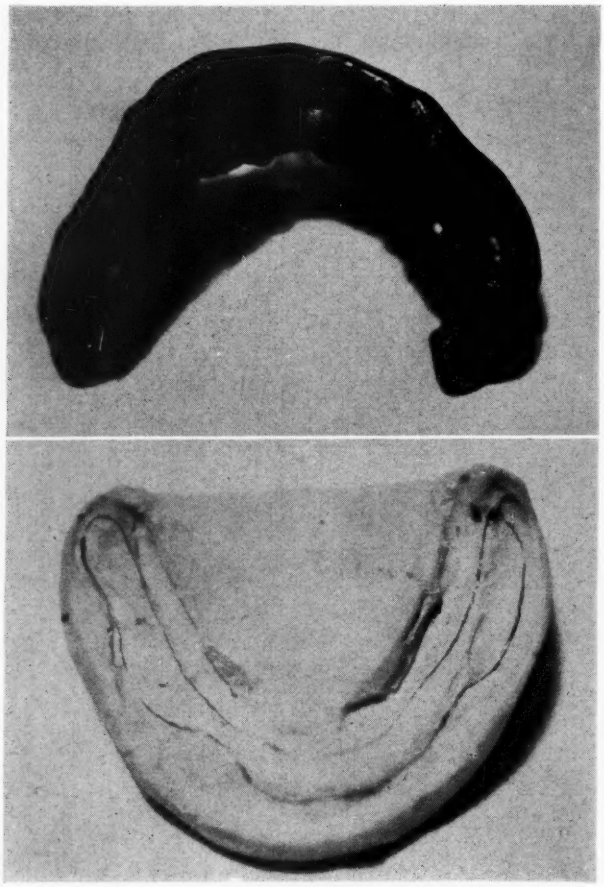

Fig. 9.

Fig. 8.—Completed sectional compound impression of exposed bony ridge.
Fig. 9.—Cast poured from the direct bone impression and outlined for the design of the implant casting.

For descriptive purposes,[11] the full lower implant denture is divided into two parts, the implant and the implant denture. The implant section is designed of a fine metal meshwork to conform to the curvatures of the mandibular ridge and is securely fastened to it by means of screws. This becomes a fixed permanent part of the mandible and is covered by the mucoperiosteum. There are two cuspid and two molar abutments extending from the implant through the soft tissue. These are constructed to receive and retain the implant denture which consists of the remaining teeth. The implant denture is a one-piece casting incorporated with clasps for retention on the abutments. This becomes identical to a removable partial denture except that it does not rest on the soft tissue. Denture base material has been eliminated; therefore bulk is no longer present.

The obvious advantages of the implant denture are complete retention, because the denture is held in place on four fixed abutments; complete stability, because in function there is no movement to the denture; complete function, because the patient does not have to learn to balance or manipulate the dentures; complete lack of bulk, because extensions of base denture material are eliminated; complete mental and physical comfort, because patients know that the dentures are fixed securely and that there is no pressure on the soft tissues, eliminating the possibility of sore spots.

Fig. 10. Fig. 11.

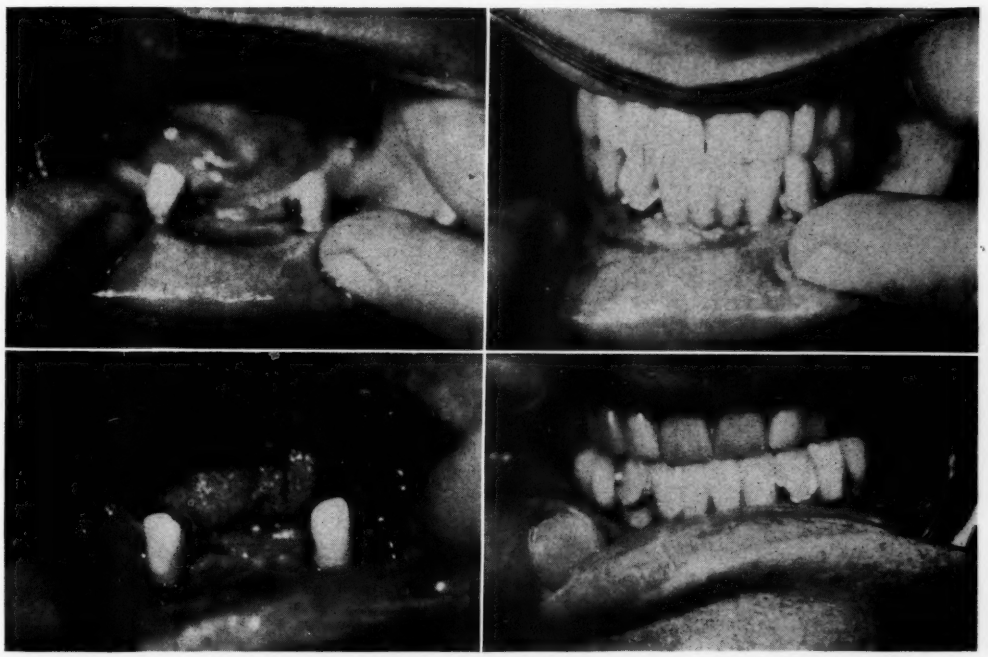

Fig. 12. Fig. 13.

Fig. 10.—Female patient with implant in situ one year.
Fig. 11.—Same patient as in Fig. 10, showing implant denture in position.
Fig. 12.—Male patient with implant in situ thirty-two months.
Fig. 13.—Same patient as in Fig. 12, showing implant denture in position.

There are two distinct phases to be considered in the application of the implant denture principles, first, the surgical phase and, second, the prosthetic phase, and each is dependent upon the other for the desired results. If good surgery is performed and the prosthesis is not adequate (in reference to correct centric relation and balanced occlusion of the dentures), we cannot expect satisfactory results. We would like to emphasize the importance of obtaining proper centric relation and balanced occlusion so that it is not taken for granted that the only important feature in the technique is the surgery. It is not our intent to discuss or advocate any particular type of surgical or prosthetic technique, but to emphasize the fact that the success of the implant denture cases will be jeopardized by using a technique that has shortcomings or inadequacies.

Two of our early cases were failures, and the implants were removed. The nature of the failures was lack of fit of the implant to the bone. Since the occurrence of these failures, an accurate method of determining the fit of the implant to the bone has been developed. The x-ray template was devised whereby intraoral findings could be accurately transferred to the cast and the cast prepared to resemble the bony ridge of the mandible.[12] In our hands, this technique proved very accurate and successful. However, we find that, in our association with many men actively participating in implant denture work, problems pertaining to cast preparation present themselves to some of these men because they are called upon to carry out a procedure completely different from their routine work. In order to make implant dentures successful in many hands and in order to solve the difficulty that some men may have, we suggest an alternative method. The dentist will be utilizing materials and following procedures with which he is basically familiar.

Fig. 14. Fig. 15.

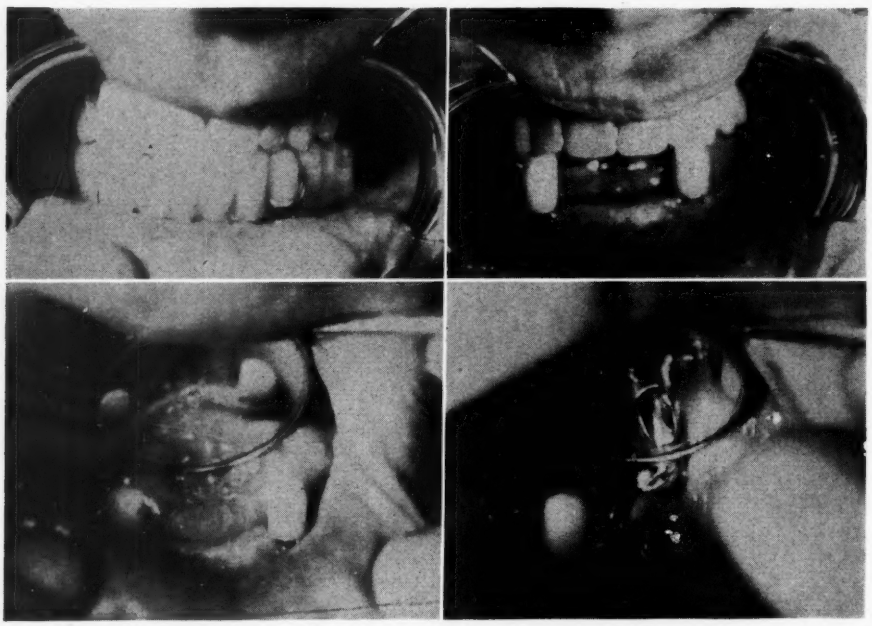

Fig. 16. Fig. 17.

Fig. 14.—Female patient with implant in situ two years.
Fig. 15.—Same patient as in Fig. 14, showing condition of tissues in anterior section.
Fig. 16.—Same patient as in Fig. 14, showing condition of tissues behind the anterior abutments.
Fig. 17.—Same patient as in Fig. 14, showing condition of tissues around posterior abutment.

This method is a two-operation procedure in which a direct impression of the bone is obtained at the time of the first operation (Figs. 8 and 9). When the implant casting is completed, a second operation is required for insertion of the implant. During the first operation an alveolectomy must be performed, when necessary, to eliminate resorption of alveolar bone beneath the implant.

### PROCEDURE FOR DIRECT BONE IMPRESSION

Primary compound impressions are obtained of the upper and lower jaws. The final accurate impressions are then obtained. Centric relation is established, and the teeth are set up for a try-in. The procedure to this point is identical to conventional denture construction.

The next step is to construct a clear plastic tray for the lower cast which covers the ridge area only. The baseplate of the lower setup is trimmed so it fits over the same area as the plastic tray.

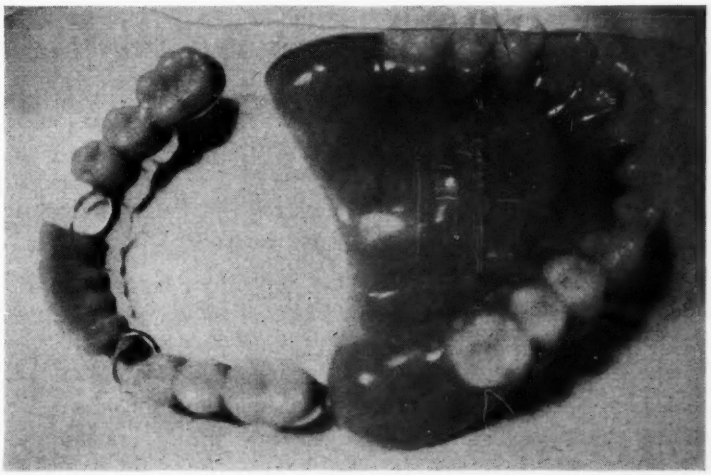

Fig. 18.—Conventional upper denture and implant lower denture ready for insertion.

The lower jaw is then anesthetized with a double mandibular block and long buccal nerve infiltrations. An incision is made along the crest of the ridge from one retromolar pad to the other cleanly through the mucoperiosteum. The mucoperiosteum is then retracted to accommodate amply the plastic tray. One side of the tray is filled with soft compound, and a sectional impression of that side is obtained. The same is repeated on the opposite side. This impression technique is followed to prevent interference of the free mucoperiosteal flaps while the impressions are being obtained.

A narrow, soft roll of beeswax is adapted to the trimmed baseplate of the lower setup which is then placed on the exposed bony ridge. The full upper setup is inserted, and the patient is directed to close in centric relation and at the desired vertical dimension. The upper and lower setups are then sealed together and removed.

The tissues are closed with a continuous type of suture.

A new cast is poured in the lower impression, the teeth are arranged in balanced occlusion, and an implant is cast on the new lower cast.

### INSERTION OF THE IMPLANT

The technique for the insertion of the implant is the same as that described and illustrated in the November, 1949, issue of the *Dental Digest*[11]:

"The patient is given a double mandibular nerve block and at the same time a long buccal nerve infiltration.

"An incision, no longer than the distal ends of the implant, is made along the crest of the ridge through the mucoperiosteum.

"The tissue is retracted just enough to encompass the width of the implant.

"The implant is now set on the bone, underneath the mucoperiosteum, and the full denture is inserted.

"The patient is instructed to close in centric relation in order that the occlusion of the abutments may be checked.

"The upper denture is then removed. Holding the implant firmly in position, starting holes are made in the bone for the insertion of the screws. The screws are inserted to secure the implant permanently to the bone.

"The mucoperiosteum is then carefully sutured over the implant."

## CONCLUSION

The most gratifying experience encountered in the practice of dentistry is to be able to satisfy the so-called "denture neurotic," the patient that other men do not want. Patients seeking implant dentures are most cooperative and have no objections to the surgical phase. If the implant fits the bone and good surgical and prosthetic procedures are followed, the cases will be successful.

In using the direct impression technique, it would seem that the patient is submitting to a needless operation. This view should not be taken too seriously, since the patient would be assured of an accurate fitting implant, and the end justifies the means. Patients have received service from implant dentures over a period of three years that conventional dentures were unable to fulfill (Figs. 10 to 18).

## REFERENCES

1. Venable, C. S., and Stuck, W. G.: Fractures—Recent Advances in Treatment With Non-electrolytic Metal Appliances, J. Indiana M. A. **31**:335-342, 1938.
2. Secord, E. W., and Breck, L. W.: Report of a Case in Which a Vitallium Plate Could Not Be Removed, J. Bone & Joint Surg. **22**:749, 1940.
3. Cameron, D. M., and Henderson, M. S.: Vitallium in Bone Surgery With Particular Reference to Clinical Irritability, Proc. Staff Meet., Mayo Clin. **15**:561-564, 1940.
4. Doherty, W. B.: Orbital Implants, With Special Reference to Vitallium, Arch. Ophth. **25**:637-642, 1941.
5. Geib, F. W.: Vitallium Skull Plates, J. A. M. A. **117**:8-12, 1941; correction, **117**: 306, 1941.
6. Smith-Petersen, M. N.: Arthroplasty of the Hip—A New Method, J. Bone & Joint Surg. **21**:269-288, 1939.
7. Koontz, A. R.: Preliminary Report on the Use of Tantalum Mesh in the Repair of Ventral Hernias, Ann. Surg. **127**:1079-1085, 1948.
8. Greenfield, E. J.: Implantation of Crown and Bridge Abutments, D. Cosmos **55**: 364-369, 1913.
9. Dahl, S. G. A.: Om möjligheten för implantation i käken av metallskelett som bas eller retention för fasta eller avtagbara proteser, Särtryck ur Odontologisk Tidskrift häfte 4, 1943.
10. Strock, A. E.: Experimental Work on a Method for the Replacement of Missing Teeth by Direct Implantation of a Metal Support Into the Alveolus, Am. J. Orthodontics **25**:467-472, 1939.
11. Goldberg, N. I., and Gershkoff, A.: The Implant Lower Denture, D. Digest **55**: 490-494, 1949.
12. Goldberg, N. I., and Gershkoff, A.: Further Report on the Full Lower Implant Denture, D. Digest **56**:478-483, 1950.

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## DISCUSSION

*Fundamentals of the Implant Denture, by N. I. Goldberg, D.D.S., and A. Gershkoff, B.S., D.D.S.*

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THE discussion of any article should include the unbiased opinion of a neutral party, unaltered by too much enthusiasm nor on the other hand lacking in it. Since it is an easy matter for one to condemn the work of others, a fair consideration of the pros and cons is essential to continued improvements in the medical sciences.

The history of implants of different materials, especially those made of metal, is stormy, to say the least. So many spectacular claims have been made in the past, with their eventual failures following, that any new technique is bound to be greeted with a "tongue in cheek" attitude. It must be stated, however, that the technique promulgated by the authors is new in most respects, is the result of their own labors, and is successful in their hands; and consequently, they deserve our respect and thanks for what they have accomplished.

The purpose of this implant is not to replace the conventional lower denture, but rather to offer some hope to those individuals for whom the conventional lower dentures, for some reason or other, have failed. It is, therefore, for the so-called impossible cases that it is used, and any success in the treatment should be applauded. I would suggest that a complete medical examination, including blood and urine tests be made, for some diseases, such as diabetes, tuberculosis, and chronic alcoholism, would tend to inhibit the healing processes.

The impressions, both preliminary and final, should be as complete and accurate as possible. Correct centric relation, as in all dentures, is most essential. If the vertical dimension is opened to any degree, the undue stress applied to the implant during mastication would tend to loosen it, and the implant would be a failure. It is therefore suggested that a slight tendency toward a closed vertical dimension be effected. The use of plastic teeth is also advocated by the authors as a means of lessening the trauma, and they feel that it is better to replace the teeth on the dentures in four or five years than to take the chance of the harsh treatment that porcelain teeth could give.

The implant technique as far as I am concerned leaves much to be desired. The use of the x-ray template has helped considerably, but I feel that preparing a cast from roentgenograms is still not the final answer to the problem. The direct impression technique which they suggest is more accurate. The external

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oblique ridge and the extreme variances of the anterior segment of the mandible present problems in measurements that are practically insurmountable. It is stated that the implant fits the bone perfectly, but I doubt it. I do believe though that a close fit is good enough, or else more failures would have occurred.

Some concern has been felt by many over the surgical procedure necessary in the placement of the implant. The first objection is usually the employment of the double mandibular block for the anesthetic. This I believe to be unfounded. I have been using this technique for many years and can see no harm in it. Conversation with eminent oral surgeons confirms this belief. The second objection involves what appears to be radical surgery in the actual insertion, but this too is unfounded. No bone or soft tissue is removed, and the implant is gently screwed into place, followed by the suturing of the soft tissues back into position. There should be no shock or trauma from this operation, and, in comparison with an alveolectomy, apicoectomy, or the surgical removal of an impaction it is relatively simple to perform and easy on the patient.

The histologic picture is still cloudy. Up to date, no complete series of experiments has been undertaken to show what the future of these implants will be. The screws frequently are exfoliated; this is a reaction of the bone to a foreign body. The implant mesh base may in time receive the same treatment. The biggest danger appears to be the possibility of seepage around the abutments and its eventual harm. We all admit that implants have been used fairly successfully by orthopedic surgeons for some time, but their implants have no direct connection with the outside and are completely covered. The authors are apparently content to rely upon clinical observations alone.

The advantages of the lower implant, as described by the authors, would appear to be a lower denture that is tight and secure with a minimum of bulk, not affected by absorption of bone and tissue. This is therefore, as far as they are concerned, the ideal lower denture for persons having difficulties with conventional dentures. The disadvantage would appear to be the possibility of infection around the screws, the mesh base, and especially the abutments.

I must consider this technique as having possibilities and would recommend that dentists use it in a limited manner. If a large number would make a few cases, the clinical picture would be clarified even more than it is now. Since the histologic information is entirely lacking, we have no idea how long these cases will remain in the mouth. The authors had the fortitude to start and carry out this procedure and should continue to bear the brunt of responsibility—let us wait for their reports five and ten years from now before passing final judgment.

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# HISTORY OF IMPLANT WORK AND A REPORT ON MANDIBULAR IMPLANTS BY THE DIRECT IMPRESSION METHOD

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IMPLANTATION of metal and bone sections into the human body has been practiced far back in the history of man. Gold, silver, and platinum have been used longest to close skull openings and to replace segments of other bones lost by disease, accident, or infection. Bone segments and pins have also been widely used with a fair degree of success.

Since the advent, in the early 30's, of stainless steel alloys of chrome and cobalt, metal implant work has been far more successful and therefore more widely used.

The principal reason for the increase in successful cases where surgical stainless steel alloys were employed is the very high tolerance of human tissues to this alloy.

During the last war and since, many new and fine techniques have been perfected, creating new fields for implantation work with highly successful results for the patients.

I have talked with a number of orthopedic surgeons who have told of many cases of patients who have been able to return to physically normal activity with implant surgery. Some of the cases were Myelin pin implants on long bones, such as the femur, tibia, radius, and ulna.

Patients suffering a complete ankylosis of the hip joint can now enjoy normal life. A new stainless steel femur head is made. The greater trochanter and lesser trochanter are implanted with a shaft of the femur implant pinned to the length of the normal bone shaft. The head of the femur is secured in the acetabulum by a heavy, triangular-shaped, splined pin.

These patients are able to resume normal walking, step climbing, and even dancing. The surgeon's principal concern is the continuing arthritic process which in several years again produces ankylosis of the joint.

Cured acrylic resins are now being used by the Armed Services for skull implantations.

## DENTAL IMPLANTS

The success of these medical implantations has led to the study and application of these procedures to the problems of dentistry, the number one of which is the lower dental arch.

Dental implantations in many forms have been attempted for the past twenty-seven years. American and British journals have carried articles which describe dental implantation since 1909.

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Dental implantations present a different problem than those elsewhere in the anatomy, because of saliva and enzymes and bacteria and food particles in solution in the saliva. Furthermore, the mucosa covering the mandible is not of uniform thickness.

In 1946, Goldberg and Gershkoff[1, 2] started working on mandibular implants and sought to overcome these problems. These men are to be commended for the progress and success they have achieved. They have solved many of the perplexing problems peculiar to the jaw of human beings who need more than a conventional type of denture.

In dentistry the big problem was seepage around the pins. The work of Goldberg and Gershkoff has been closely scrutinized regarding this problem, as well as the one of the general condition of the bone, especially in the areas where screws are set. No pathologic condition, infection, nor harmful results have been encountered in all of the cases they have reported.

My technique differs from theirs, principally in the manner of impression making and centric relation registration. My work is done by direct impression of the exposed mandible.

## EXAMINATION

On the patient's first visit, a thorough x-ray examination is made. This consists of a complete full mouth roentgenogram to be studied for spiculae and gross areas of uneven cortical bone on the crest of the ridge. The films are also examined for pathology, compactness of the bone, and relationship of the mandibular canal to the crest of the ridge. Lateral jaw roentgenograms are also made for an evaluation of the gross bone anatomy.

The patient is then referred to his physician and laboratory for a complete report on the physical condition. This includes a chest roentgenogram, electrocardiogram, complete blood picture, stool examination, and a search for any debilitating diseases.

If the prospective patient's physical condition is found to be satisfactory, the procedure for making an implant may be employed.

## TECHNIQUE

1. A complete upper and lower impression is made the same as for conventional prostheses.
2. The centric jaw registration is made.
3. The tooth arrangement is made in wax and corrected to satisfy all prosthetic requirements.
4. An outline is made on the mandibular cast area to be covered by the implant casting. This area is similar in appearance to that of a distal extension lower partial denture which has two saddles extending posteriorly from the cuspids through the second molars. The widest bearing area is in the first and second molar region. The bicuspid area narrows buccolingually and anteriorly toward the cuspid area. The anterior portion of the casting resembles a lingual bar in that it is narrowed to the width of the crest of the ridge; thus, the anterior section appears simply to connect the two posterior saddles.

5. An acrylic tray is then cured to cover the area thus outlined. The acrylic tray is set on the cast, and the six lower anterior teeth are reset. The centric relation registration is established on the acrylic tray from cuspids distally by adding fast-curing acrylic distal to the cuspids. The tray, with the anterior teeth and the posterior jaw relation corrected on the articulator, becomes the tray for the direct impression of the exposed mandible. For asepsis, the tray and the upper try-in are soaked in a cold sterilizing solution for one hour before surgery.

6. The patient is prepared for the surgical exposure of the mandible by premedication. One hour before surgery, 1½ grains Nembutal and 100 mg. Banthine are administered. This will check the flow of saliva. Two mandibular nerve block injections are made. The anesthesia must be profound.

7. The incision is made according to the anatomy of the ridge. It is made either over the crest of the ridge or buccally and labially to the crest of the ridge. This decision must be predetermined. Retraction is done carefully to carry all the mucoperiosteum intact. Tissues on the lingual aspect are ligated, and sutures are tied across the floor of the mouth to hold the tissues out of the field of operation and to reduce the handling.

8. All spiculae and unsmooth areas are removed by using Hein chisels and files.

9. The impression tray is seated on the mandible and checked for tissue impingements. The tray is corrected with sterile vulcanite burs. The upper try-in and lower tray are seated. The approximation of the incisal planes is checked, and centric relation is recorded. At this time discrepancies will appear, but they are corrected with an impression material. The materials of choice for these impressions are plastics or semiplastics which are not affected by blood and mucus which would wash the surface of the material on contact. Additions to these impressions may be made for correction. This gives the accurate impression of bone and a corrected centric relation record made under a slight pressure by a closed mouth denture technique.

10. The wound is dusted with penicillin powder, and the tissues are sutured. Swelling and pain, if any, are controlled by conventional methods. The tissues are allowed to heal. The periosteum must become reattached to the bone before the second opening is made. The time required for this varies with different patients.

11. The laboratory procedure is followed through. All castings are x-rayed for imperfections. The implant casting and the upper casting are sterilized for one hour. The patient is again prepared as before. The incision is made, and the tissue is retracted and held away by sutures. The steriie casting is seated on the mandible. The lower superstructure is seated on the casting. The upper try-in is also seated, and the centric relation is checked. The lip-to-tooth relationship of the lower incisors, the vertical dimension, and the tooth-to-ridge relationships are checked.

12. The implant casting has included in it, in the bicuspid or molar area, a boxing to receive a screw. These screws are 3 to 7 mm. in length, slightly less

than the diameter of a No. 5 bur. A No. 5 bur is used to slowly tap out holes in the mandible to receive screws. Grindings are washed out with sterile water. Screws are then seated well into the boxing of the casting.

13. The tissues are coapted and sutured.

The tissues lay back into position easily, and the edges are approximated; thereby, healing takes place quickly. A high protein diet is ordered for these patients. Eggnogs, milk, and cheese dishes supply a large part of the diet. Vitamin and mineral substance must always be included in diets when any bone surgery is done. This is necessary before the surgical procedure and is continued long after it.

14. In as few as nine days, the healing has been sufficient to complete the lower superstructure. The centric relation is corrected in the upper denture, and it is processed. Both structures are seated at the same visit. The clasps on the lower posts are loosened so no sensation of pull or torque on the jaw is noticeable to the patient. A light bland diet is continued only according to the sensations of tenderness or pain by the patient.

## INDICATIONS FOR LOWER IMPLANTS

Implants are indicated for patients in good health who have been dental "cripples" since the loss of their teeth.

These include people with a poor mental attitude toward conventional dentures and those with nervous muscular habits, large tongues, gagging tendencies, knife-edge ridges, no ridge, spiculae, sharp spines, and those who just won't try, like my own father. These patients are legion, and all of us know many of them.

## DISADVANTAGES OF IMPLANTS

The only disadvantages I know of now are economics and poor health.

It is quite a lengthy technique as much time is spent in checking and watching these patients.

## COMMENT

The work has been done for over three years. It is still in the experimental clinical research class. But the essence of it all is how pleased the patients are that have received it; no longer do they have to forego the pleasure of normal mastication of well-prepared food. Patients have been examined, x-rayed, and evaluated, and in no instance has pathology or infection occurred.

## REFERENCES

1. Goldberg, N. I., and Gerskoff, A.: The Implant Lower Denture, D. Digest **55**:490-494, 1949.
2. Goldberg, N. I., and Gershkoff, A.: Further Report on the Full Lower Implant Denture, D. Digest **56**:478-483, 1950.

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# COOPERATION OF ORAL SURGEON AND PROSTHODONTIST IN RENDERING ARTIFICIAL DENTURE SERVICE

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THE paramount justification for the practice of dentistry is the health, comfort, and welfare of the patient, and the remarks which I shall make in this discussion will be based upon this premise.

Complete cooperation between any two branches of a profession such as ours can result only when there is a complete understanding of the problems of each and a willingness on the part of each to aid the other in every manner possible.

The majority of oral surgeons with whom I have worked, in connection with the rendering of artificial denture service, have been cooperative, and many have willingly changed certain practices of long standing when the benefits of such changes were demonstrated.

There is one feature of dental service which has been given too little attention, both in clinical and private practice. This pertains to the dental examination and the formulation of treatment plans for patients who will need artificial denture service.

I refer to this phase of dental practice because it is not uncommon for some prospective edentulous or semiedentulous patients to go directly to the oral surgeon before contacting the dentist who is to make their artificial dentures. In too many instances natural teeth are extracted without the patient's being informed of the procedure which should be followed.

This practice does not coincide with modern concepts of artificial denture service and may, in some instances, contribute to the rendering of an inferior service.

Except in cases of accident or acute pathology, patients who are to receive artificial denture service should always be examined by the dentist who is to render that service before any operative procedures are decided upon or instigated. This is logical because artificial denture service is a very complex and exacting phase of dental practice in which the examination and treatment plan are vitally important factors.

Not unlike the builder who will be responsible for a finished structure, the prosthodontist is the one who has the long-range responsibility of providing artificial denture service to the patient, and, as with a building, the foundation is one of the most important factors to be considered.

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A topic discussion as part of a symposium, read before the Section on Full Denture Prosthesis and the Section on Oral Surgery, at the ninety-first annual session of the American Dental Association, Atlantic City, November 1, 1950.

Reprinted from the Journal of Oral Surgery 9:292-294, 1951, with additions by the author.

When the prosthodontist's examination and treatment plan are incorporated in the initial treatment plan, it is possible that the resulting denture foundations will contribute to better artificial denture service for the patient and that the prestige of all who have participated in solving the patient's dental problem will have been enhanced.

There are other reasons why the prosthodontist should meet the prospective denture patient before any operative procedures are instigated.

A complete understanding on the part of the patient regarding the nature of artificial dentures and their many shortcomings, previous to the loss of the natural teeth, is one of the most important factors in the attainment of a successful end result. The mind plays an important part in acceptance and tolerance of artificial substitutes for portions of the human body, and the time to prepare the prospective edentulous patient for artificial dentures is previous to the loss of his remaining natural teeth.

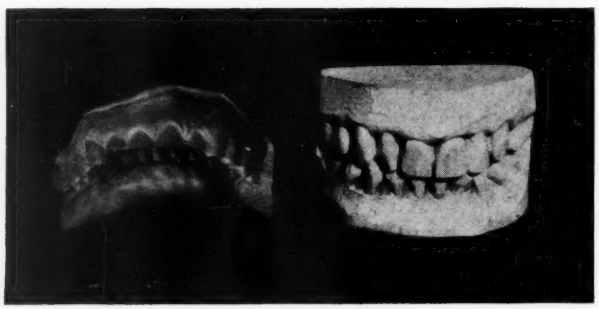

Fig. 1.—The labial size, form, arrangement, and relationship of the natural anterior teeth may be recorded by molding softened impression material against the labial surfaces while the dental arches are maintained in centric occlusion. An artificial stone cast is made from this impression.

Pre-extraction records constitute one of the best aids to the rendering of artificial denture service. These records are of inestimable value during original denture construction and later serve to show the patient the changes which have occurred as the result of edentulous ridge resorption. They also serve as a guide when relining old dentures and constructing new ones.

It is regrettable that the making of such records is not a routine procedure with all dentists who construct dentures for patients. This service is not the responsibility of the oral surgeon but of the prosthodontist, providing he is given the opportunity to render it.

Although pre-extraction records are usually associated with the construction and maintenance of artificial dentures, such records may prove to be of great value to dentists and to plastic surgeons in cases of facial mutilation.

I would suggest the name "profile and dental characteristics records" and that the first of such records be made by dentists early in the adult life of patients.

The dental examination for practically all patients who will require partial dentures and for many who will require full dentures should include the making of accurate study casts, and in many instances these casts should be mounted in an articulator.

Study casts not only reveal many conditions which may not be evident from a visual examination of the mouth, but they may be used by the prosthodontist and by the oral surgeon in outlining their treatment plans and for explaining to the patient the reasons for certain proposed operative procedures.

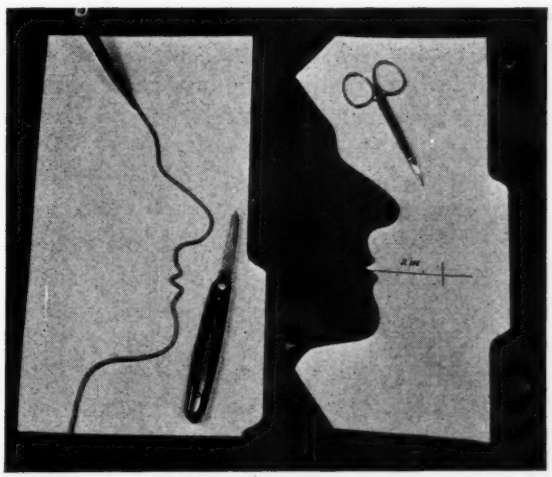

Fig. 2.—Roentgenograms, photographs, parallel light rays, or soft wire (as illustrated) may be used to make the profile record card. In artificial denture construction this record is most useful when it is made with the teeth in occlusion at the proper vertical dimension for the patient. Patients presenting closed or decreased vertical dimension should be provided with wax or modeling compound splints between the natural teeth before the profile record is made.

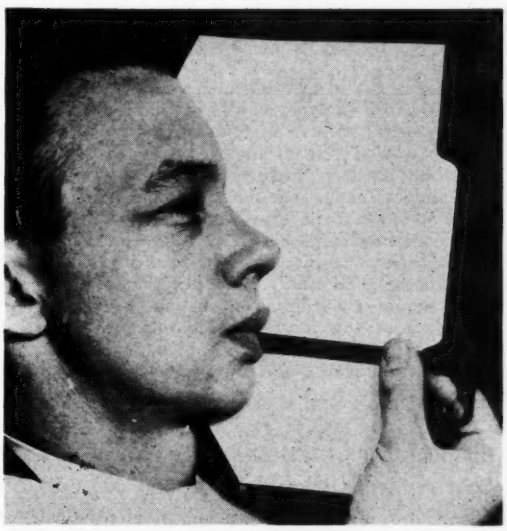

Fig. 3.—While the profile card is maintained in position on the face, a straight edge is placed against the incisal edge of the most desirably positioned upper central incisor. A pencil line is drawn on the profile card; the upper surface of the straight edge is used as a guide. This records the vertical position of the incisal edge in relation to the profile.

Immediate artificial denture service, in which the surgical procedures are performed by one dentist and the prosthetic service by another, calls for complete cooperation on the part of both dentists if satisfactory end results are to be expected.

The primary concern in this branch of dental service relates to the reshaping of the osseous substructures contiguous to the remaining natural teeth that are being extracted and also to the use of sutures on the soft tissues.

Alveolectomy is not necessary in all cases and should be avoided when possible. Except in case of disease or injury the only reason for altering edentulous ridge form is to meet the requirements of prosthetics, and the prosthodontist is best qualified to prescribe such alteration.

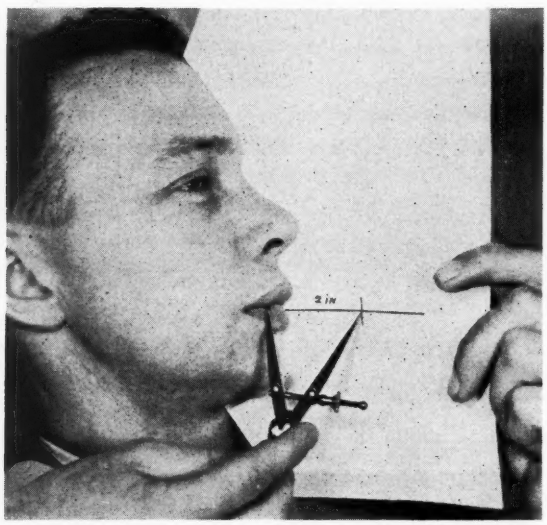


Fig. 4.—With dividers adjusted to a fixed distance on a steel ruler (I prefer 2 inches for all cases) and with the profile record card correctly positioned on the face, the anteroposterior position of the selected upper central incisor in relation to the profile is recorded. One point is placed on the labial surface of the central incisor, near the incisal edge, while the other point is used to indent the profile card on the previously made line. The long axis inclination of the labial surface of the central incisor should be sketched on the record card just above the horizontal line. Sketches of tooth form, high and low lip lines, and lip and tooth relationship when the mouth is open slightly, together with other data of importance, should be recorded on the profile record card. The finished record should be shown to the patient and the detailed markings explained to him. This practice aids in preventing certain post-extraction misunderstandings between patient and dentist. Informal snapshots made by the patient's family previous to loss of the natural teeth are also of great value. Many facial profile deformities which are associated with the wearing of artificial dentures are the result of positioning the artificial upper anterior teeth too far back in the mouth. A properly made pre-extraction profile record will aid the dentist in avoiding this error.

Conservation of the oral tissues should be the aim of all operators, and surgical reduction of denture-bearing areas should always be kept to a minimum.

After the prosthodontist has determined what, if any, alteration of ridge form is necessary and has established the desired form on the master cast, he should make a duplicate cast to serve as a guide for the oral surgeon. An impression is made of the completely altered master cast after the boil-out procedures have been completed in the laboratory and before the cast has been tin-foiled.

The duplicate cast is made of artificial stone and may be used for making a transparent base to serve as a surgical guide. The oral surgeons with whom I cooperate are able to produce excellent results by observing the duplicate altered cast, and, therefore, it is no longer necessary to construct transparent surgical guide bases.

It is the responsibility of the prosthodontist to furnish the oral surgeon with whatever guides may be necessary to enable him to form a ridge which will fit the denture.

The inner surface of an immediate denture should present a smooth and well-rounded concave form so that it may serve as a suitable matrix for the formation of the edentulous ridge as it heals. The presence of projections which extend into tooth sockets interferes with the filling in of those areas during the healing process, and it definitely accentuates resorption of the osseous substructures. In this regard the use of saddle-type pontics in fixed bridgework results in less edentulous ridge resorption than does the use of pointed root-type pontics.

The improper use of sutures may have an undesirable effect upon artificial denture base extensions in the buccal and labial sulcus regions.

Deep buccal and labial sulci usually contribute favorably to denture base retention and stability because they permit the use of prominent buccal and labial denture flanges.

Surgical procedures, which may involve the use of sutures, should, therefore, be designed to preserve the maximum normal depth of these sulci, especially in immediate denture service.

It is not uncommon for some oral surgeons to remove too much of the interseptal tissue over the crest of the ridge, and then bring the edges into apposition with tight suturing following alveolectomy. This procedure usually results in a shortening of the sulcus depth that was utilized when constructing the immediate prosthesis. This immediately sets up a condition of denture border overextension which can be detrimental to the comfort of the patient and to the prestige of both the oral surgeon and the prosthodontist.

Sutures may be used without shortening the vestibule depth if the oral surgeon will delay shortening the interseptal tissues until after the osseous structures have been reshaped and then remove only that portion which overlaps the undisturbed section while light finger pressure is being applied sulcus-wise in the vestibule region.

It is my opinion that sutures are seldom necessary under immediate dentures, provided the patient can be depended upon to follow directions and provided the inner surface of the denture has been properly prepared to serve as a desirable matrix over the surgically altered areas. Some of the best formed ridges have resulted from using only the denture base to support the soft tissues during the healing process.

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# THE INFLUENCE OF COMPLETE DENTURES UPON TASTE PERCEPTION

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DO YOUR patients experience an interruption of taste sensations upon the insertion of dentures?

The organs of taste were first discovered in mammals in the year 1867. Since that time, considerable research has been done, principally upon the taste areas on the tongue. To the best of my knowledge, no one has attacked the problem of ageusia as it relates to dentures. My paper deals with the sense of taste and the influence that complete dentures may have upon it.

The ability to originate sensations is common to all parts of the body. Impulses are sent to the brain and recorded regardless of their nature. These sense organs have been classified into two main groups, those belonging to the common sensibility of the body and those forming the special sense organs.

## SPECIAL SENSES

The special sense organs from a structural standpoint are organs whose cells are so specialized that they are subject to stimulation by only a particular category of external changes. These organs are ordinarily arranged under five heads, each with an adequate stimulus and productive of a special sensation. They are the organs of touch, taste, smell, sight, and hearing.[1,2] Some investigators classify the senses of heat, cold, and pain as special senses separate from that of touch.

Schuyler[3] stated: "Systemic evidence of dietary and vitamin deficiencies is commonly associated with need of efficient dental service. Continued oral discomfort may seriously affect the general nervous system resulting in neurosis or impaired function of an organ of the body." Thus, we have the first factors which may influence our taste perception.

## PHYSIOLOGY

The physiologic mechanism involved in the sense of taste includes the tongue, the soft palate, the gustatory nerves (chorda tympani and glossopharyngeal and the lingual branch of the fifth), their cortical connections, and nerve cells in the gray matter of the fourth temporal convolutions.

According to the literature, the investigators confined their discussions to the taste areas of the tongue but stated that in different individuals the taste area may

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be extended to the mucous membrane of the hard palate, anterior surface of the soft palate, uvula, the tonsils, posterior wall of the pharynx, epiglottis, and the anterior and posterior half arches. Parker[4] stated: "When the mouth of a normal adult is explored with solutions of sapid substances, many parts such as the lips, the gums, the floor, the lower surface of the tongue, the inner surfaces of the cheeks, and the hard palate are found to be insensitive to taste. According to the older workers, the uvula was regarded as having a gustatory function. Kiesow and Hahn (1901) have shown that it is not concerned with taste." The tonsils and the pillars of the fauces have been under dispute, but Kiesow and Hahn regarded them as usually being insensitive to taste. According to Parker,[5] the following parts are concerned with taste: the beginning of the gullet, the region of the arytenoid cartilage within the larynx, the epiglottis, the soft palate, and particularly the tongue. He also stated that taste buds have been identified within these areas. The only description of taste buds found thus far has been of those located on the tongue.

## ANATOMY

The tongue is covered by mucous membrane continuous with that lining the oral cavity. The dorsum of the tongue presents a series of papillae richly supplied with blood vessels and nerves. Of these there are four varieties, the filiform, the fungiform, the circumvallate, and the foliate.

1. The filiform papillae are the most numerous and cover the anterior two-thirds of the tongue. They are conical or filiform in shape and covered with horny epithelium, but they do not contain taste buds.

2. The fungiform papillae are found at the tip and sides of the tongue and are less numerous but larger than the filiform papillae; they resemble small knobs and are deep red in color.

3. The circumvallate papillae, usually eight to ten in number, are situated at the base of the tongue in the form of a V.

4. The foliate papillae lie on either side of the edge of the human tongue and close to its root. They form a series of from three to eight vertical parallel ridges. Each ridge is abundantly supplied with taste buds which open into the ditch between the ridges. Heindenhain[6] has shown that the buds are arranged in more or less vertical rows on each papillar fold.

## HISTOLOGY OF TASTE BUDS

Small ovoid bodies are embedded in the epithelium covering the mucous membrane of these areas, and from their relation to the gustatory nerves they are regarded as their peripheral end organs and so are known as the taste buds. The ovoid base rests on the tunica propria; its apex comes to the epithelium where it presents a narrow funnel-shaped opening, the taste pore. The wall of the bud is composed of elongated curved epithelium. The interior contains narrow, spindle-shaped neuroepithelial cells provided at their outer extremity with stiff hairlike filaments which project into the taste pore. The neuroepithelial cells are in

physiologic relation with the nerves of taste. After entering the taste bud at its base, the terminal branches develop fine tufts which come into contact with the cells. It is reasonable to assume that the taste buds are connected with the nerves of taste from the fact that they degenerate after the nerves of taste are severed. Hermann pointed out that the cells of the taste buds are probably undergoing continued change. This is indicated by the presence of cells in all stages of growth and of a considerable number of leukocytes. The taste buds on the tongue are found in conjunction with fungiform, foliate, and circumvallate papillae. The lingual papillae were first described by Malpighi in 1664. Loven and Schwalbe discovered the taste buds in mammals in 1867, but to Loven belongs the distinction of having discovered and described the taste buds in man in 1867. It was also pointed out that there is a much wider distribution of taste buds in the fetuses, infants, and children than in the adult. It was emphasized by Stahr in 1902 that there is a gradual shift of the center of lingual taste from the tip of the tongue to the region of the circumvallate papillae.[7] Study by Heiderich in 1906 placed the number of taste buds per circumvallate papilla at 248; he also found an additional thirty in the trench wall. The work by Heiderich includes specimens only up to the age of 20 years.[8]

## GUSTATORY NERVES

The nerves of taste are the glossopharyngeal, which supplies the back of the tongue, and the lingual branch of the fifth and the chorda tympani, which supply the front part of the tongue. The posterior palatine branch of the palatine nerve which originates in the sphenopalatine ganglion and the lingual branch of the glossopharyngeal nerve both supply the soft palate. We are not certain at this time which carries the sense of taste in the soft palate area.

All these fibers are probably connected with a continuous column of gray matter in the brain stem which represents the splanchnic afferent nucleus of the fifth nerve, the nervus intermedius, and the glossopharyngeal nerve.[9]

Clark stated that the sympathetic nervous system can be disregarded as a direct factor in the maintenance of taste buds. It was brought out by Olmsted that taste buds tend to disappear if the nerves are severed or interrupted. This occurs through phagocytic action, and the taste buds will regenerate or reappear through fission if the nerves are restored.[10] Thus we may lose some taste sensation for a time if the nerves are seriously impaired. All the special sense organs are closely allied. While each has its individual function to perform, the interruption of this sense will cause the remaining ones to become more acute, probably through special training. We have all observed this at some time or other. Each of our other special senses has a direct bearing upon the sense of taste, but I fail to see where any one or all of them can substitute for the sense of taste.

## TASTE PERCEPTION

The sense of smell is very influential in the taste of foods. If the smell pleases us, we anticipate the taste of the food with a great deal of relish. If our sense of

smell is impaired, so is our taste. It has been stated that our so-called tastes should be designated as flavors, as they are not only dependent upon the gustatory nerves, but on the sense of smell as well. Our senses here are so closely allied that we sometimes do not know whether we are smelling or tasting substances. For instance, ether is an odorless substance. We actually taste it rather than smell it. The same is true of other volatile oils in some foods and other substances. You can taste as well as smell fresh coffee when it is being brewed.[11]

The touch of food also has its influence; for instance, wilted lettuce in a salad or strings on the string beans may cause us to alter our taste for the food. Sight influences taste, for if the food is prepared and served in a delicate pleasing manner, our appetite is whetted in anticipation.

Hearing may influence taste also. On a warm day, when you hear the tinkle of ice in a glass in the next room, you can taste the contents.

Heat and cold also influence the taste of certain foods. This reaction is usually perceptible through the palatal area. A full palatal coverage, well insulated, may preclude this reaction. Metallic and alkaline tastes are considered as separate taste sensations by some investigators.[12] Tastes, like odors, are caused by chemicals being dissolved in liquids about the sense organs. A person cannot taste a piece of dry sugar or salt unless a bit has been dissolved. When dissolved, these liquids can penetrate the taste pore, and the cell reacts to the chemical.

Different parts of the tongue are sensitive to different tastes. This suggests that there may be a different kind of organ for each taste. At the tip and front edges, the tongue is especially sensitive to sweet and salty tastes. On the side it is more sensitive to sour and at the back to bitter. Coffee with sugar first tastes sweet, then bitter, as it proceeds posteriorly. The center surface of the tongue is not as sensitive as the sides. Our sense of taste lessens as we grow older, particularly to sweet and salty foods. There is no doubt that the stimulating effect of any chemical substance on the taste nerves has a relation to its chemical constitution. A sour taste is determined by the presence of H ions, an alkali taste by the OH ions. We do not know or understand the law which determines whether any given substance shall have a taste at all or what the taste shall be.[13]

I am indeed indebted to several members of this group for information and experiences volunteered on the subject. It was pretty much the consensus that the mastication of foods upon the anterior teeth is inadequate, and therefore the juices or flavors do not penetrate the taste pores. Stahr has observed that there is a gradual shift of the centers of taste to the posterior side of the mouth.

The principal taste centers are on the lateral and dorsal surfaces of the tongue.[14] It is quite possible then that an irritation, pressure, or substance on the surface of the lower denture may interfere with the sense of taste. Some of you will hasten to remark, "But what about the single upper denture?" We know that there has been loss of taste sensations when a single upper denture has been placed. What has caused it? Any foreign substance on the surface of the denture which stings or has an odor may interfere with the normal taste of foods. The thickness of the denture, lack of rugae, insulation against heat and cold, all interfere with the sense of taste. Mones[17] wrote a year ago that in his opinion

Jacobson's organ was partly responsible for some of the taste sensations. Immediately over the incisive foramen at the lower edge of the septal cartilage is a depression, the nasopalatine recess. In the septum close to this recess a minute orifice may be seen. It leads into a blind pouch, known as the organ of Jacobson. This is known also as the vomeronasal organ; it is well developed in some of the lower animals but is rudimentary in man.[15,16] Mones also stated that "taste buds are also distributed on the soft palate, epiglottis and even the larynx. Because a barrier obstructing the palatal taste buds is present in full denture construction, it necessarily follows that some loss of taste must be resultant."[17]

We unconsciously rub our food against the hard palate with the tongue while tasting foods. This brings the food substance into intimate contact with the taste pores on the tongue. The hard palate is covered with stratified squamous epithelium. The fibrous tissue beneath it contains many mucous glands, the palatine glands.[18] These glands also extend through the region of the soft palate. This unconscious act plus the presence of glands within the area may cause some to mistake it for a taste area.

| | | | | TASTE AREAS | | | |
|---|---|---|---|---|---|---|---|
| AGE | SEX | DENTURES WORN | TASTE INTERRUPTED | HARD PALATE | SOFT PALATE | BUCCAL FOLD | REMARKS |
| 19 | F | YES | NO | NONE | NONE | NONE | CLEFT PALATE |
| 29 | F | " | YES | " | SOUR | " | |
| 34 | F | " | NO | " | *1 2 3 | " | |
| 36 | F | " | YES | " | NONE | " | |
| 36 | M | " | " | " | " | " | |
| 39 | M | " | " | " | " | " | |
| 39 | M | " | " | " | " | " | |
| 41 | M | " | " | " | SOUR | " | |
| 42 | M | " | " | " | " | " | M-DISATROPHY |
| 49 | F | " | " | " | " | " | |
| 55 | M | " | " | " | " | " | |
| 57 | F | " | " | " | NONE | " | |
| 58 | F | " | " | " | SALT | " | |
| 58 | M | " | NO | " | SWEET | " | |
| 58 | F | " | YES | " | NONE | " | |
| 60 | M | " | " | " | SOUR | " | |
| 64 | F | " | " | " | NONE | " | |
| 65 | F | " | NO | " | SOUR | " | |
| 65 | F | " | " | " | " | " | CLEFT PALATE |
| 68 | F | " | " | " | " | " | |
| 73 | M | " | " | " | " | " | |

NOTE-* 1-SWEET 2-SALT 3-SOUR 4-BITTER

Chart 1.—Taste perception of denture wearers.

## CLINICAL INVESTIGATION

A limited amount of clinical investigation has been done by Dr. John Horan of the Department of Neurology, University of California Medical School, and myself. The purpose of this investigation was to determine the presence or absence of taste buds in the hard and soft palatal areas and the mucobuccal folds. Our clinical material included both male and female, dentulous and edentulous patients, and all were over the age of 18 years. Some had experienced interference in taste perception upon the insertion of dentures.

The materials used for determining taste perception were of the standard type, i.e., sweet, salty, sour, and bitter, and were made up in the hospital pharmacy. The materials were: sweet, 2 Gm. of sugar in 100 c.c. of distilled water; salt, 1 Gm.

of sodium chloride in 100 c.c. of distilled water; sour, 0.4 per cent solution of muriatic acid; bitter, 0.005 Gm. of quinine in 100 c.c. of distilled water.

Our clinical material is divided for the purpose of study into two groups, denture wearers and nondenture wearers. Of the denture wearers, a majority reported taste interference (Chart 1). It will be noted that there was no taste perception on the hard palate or mucobuccal folds. It will also be noted that over one-third had no taste perception on the soft palate either. The remainder reacted principally to sour. In only three instances were sweet and salt reactions noted.

| | | | | TASTE AREAS | | | |
|---|---|---|---|---|---|---|---|
| AGE | SEX | DENTURES WORN | TASTE INTERRUPTED | HARD PALATE | SOFT PALATE | BUCCAL FOLD | REMARKS |
| 18 | M | NO | NO | NONE | *1234 | NONE | |
| 18 | M | " | " | " | 123 | " | EPILEPSY |
| 18 | F | " | " | " | 1234 | " | |
| 19 | M | " | " | " | 1234 | " | |
| 19 | M | " | " | " | 123 | " | |
| 19 | F | " | " | " | 1234 | " | |
| 19 | M | " | " | " | 1234 | " | |
| 20 | F | " | " | " | 2 | " | |
| 20 | M | " | " | " | 123 | " | |
| 20 | F | " | " | " | 123 | " | |
| 20 | M | " | " | " | 123 | " | |
| 20 | M | " | " | " | 1234 | " | |
| 21 | M | " | " | " | 1234 | " | |
| 21 | M | " | " | " | 123 | " | |
| 21 | M | " | " | " | 123 | " | |
| 21 | M | " | " | " | 1234 | " | |
| 21 | M | " | " | " | 123 | " | |
| 21 | M | " | " | " | 1234 | " | |
| 23 | F | " | " | " | 123 | " | |
| 23 | M | " | " | " | 123 | " | |
| 24 | F | " | " | " | 123 | " | |
| 24 | M | " | " | " | 123 | " | |
| 24 | M | " | " | " | 123 | " | |
| 26 | F | " | " | " | 123 | " | |
| 26 | F | " | " | " | 123 | " | |
| 26 | M | " | " | " | NONE | " | |
| 26 | M | " | " | " | " | " | |
| 28 | M | " | " | " | 12 | " | |
| 28 | M | " | " | " | 1234 | " | |
| 28 | M | " | " | " | 123 | " | NEUROSIS |
| 29 | M | " | " | " | 123 | " | |
| 29 | M | " | " | " | 123 | " | " |
| 31 | F | " | " | " | 123 | " | " |
| 33 | F | " | " | " | 123 | " | |
| 34 | M | " | " | " | 123 | " | |
| 34 | F | " | " | " | 123 | " | MIGRANE |
| 35 | M | " | " | " | 1234 | " | |
| 36 | F | " | " | " | 1234 | " | EPILEPSY |
| 36 | M | " | " | " | NONE | " | |
| 38 | M | " | " | " | 23 | " | |
| 43 | F | " | " | " | 1234 | " | |
| 43 | F | " | " | " | NONE | " | LEPROSY |
| 44 | M | " | " | " | 3 | " | |
| 47 | F | " | " | " | 12 | " | |
| 48 | M | " | " | " | 123 | " | |
| 54 | M | " | " | " | 23 | " | |
| 58 | F | " | " | " | 2 | " | |
| 61 | F | " | " | " | NONE | " | |
| 75 | M | " | " | " | " | " | |

NOTE-* 1-SWEET 2-SALT 3-SOUR 4-BITTER

Chart 2.—Taste perception of nondenture wearers.

Of those patients tested who were not denture wearers, approximately 12 per cent had no taste perception on the hard or soft palate or on the mucobuccal fold (Chart 2). Approximately 25 per cent reacted to all four taste sensations.

The majority however reacted to sweet, salt, and sour. It will also be noted that as age increased, taste perception on the soft palate decreased.

## SUMMARY

1. Taste, as we ordinarily think of it, is dependent upon all our special senses.

2. Without the sense of smell we have only our basic tastes, namely, sweet, salty, sour, and bitter.

3. In addition, taste perception is influenced by the age, health, attitude, or hunger of the individual.

4. The sense of touch and temperature are also closely allied with the sense of taste.

5. There is a much wider distribution of taste buds in the fetus, infant, and children than in the adult. Our sense of taste diminishes, therefore, as we grow older.

6. There is a gradual shift of taste from the tip of the tongue to the region of the circumvallate papillae. Our sense of taste of sweet and salt diminishes, and the sour is more pronounced.

7. Complete loss of taste, or ageusia, is known to accompany hysterical and other abnormal nervous states. It may be temporary, or, in cases of certain lesions, the sense of taste may be permanently destroyed.

8. The sense of taste may be interfered with or even interrupted by the interjection of an outside stimulus such as a denture or dentures.

9. Pressure or pain acting as a counterirritant may interrupt the sense of taste.

10. Mastication of food on the anterior teeth or undermastication of food may preclude the actual penetration of the material or food in solution into the taste pore.

## CONCLUSION

We have been unable to find any evidence to substantiate the contention that there are taste buds within the denture base area, upper or lower. It is entirely possible that in some individuals, where the denture has been overextended onto the soft palate, taste perception may be interfered with due to the pressure, pain, or the actual covering of taste buds in the area. However, to date, we have not demonstrated the presence of taste buds this close to the distal border of the hard palate.

## REFERENCES

1. Wiggers, Carl J.: Physiology in Health and Disease, ed. 3, Philadelphia, 1939, Lea & Febiger, p. 201.
2. Parker, George H.: Smell, Taste, and Allied Senses in the Vertebrates, Philadelphia, 1922, J. B. Lippincott Company, pp. 13-14.
3. Schuyler, Clyde H.: Full Denture Service as Influenced by Tooth Forms and Materials, J. Pros. Den. **1**:33-37, 1951.
4. Parker, George H.: Smell, Taste, and Allied Senses in the Vertebrates, Philadelphia, 1922, J. B. Lippincott Company, p. 132.

5. Ibid., p. 133.
6. Ibid., pp. 111-113.
7. Ibid., pp. 110-111.
8. Ibid., pp. 114-115.
9. Howell, William H.: A Textbook of Physiology for Medical Students and Physicians, ed. 11, Philadelphia, 1930, W. B. Saunders Company, pp. 295-296.
10. Parker, George H.: Smell, Taste, and Allied Senses in the Vertebrates, Philadelphia, 1922, J. B. Lippincott Company, p. 127.
11. Howell, William H.: A Textbook of Physiology for Medical Students and Physicians, ed. 11, Philadelphia, 1930, W. B. Saunders Company, pp. 297-298.
12. Parker, George H.: Smell, Taste, and Allied Senses in the Vertebrates, Philadelphia, 1922, J. B. Lippincott Company, p. 134.
13. Starling, Ernest H.: Starling's Principles of Human Physiology, ed. 5, Philadelphia, 1930, Lea & Febiger, pp. 487-489.
14. Greisheimer, Esther M.: Physiology and Anatomy, ed. 3, Philadelphia, 1936, J. B. Lippincott Company, p. 310.
15. Spitzka, Edward A.: Edition of Gray, Henry: Anatomy, Descriptive and Applied, Philadelphia and New York, 1913, Lea & Febiger, p. 1083.
16. Parker, George H.: Smell, Taste, and Allied Senses in the Vertebrates, Philadelphia, 1922, J. B. Lippincott Company, pp. 92-100.
17. Mones, Jerome: Jacobson's Organ—Why Do Full Upper Denture Wearers Experience Loss of Taste and Smell? D. Survey **26**:185-186, 1950.
18. Cunningham, Daniel J.: Textbook of Anatomy, ed. 3, New York, 1909, William Wood & Company, p. 999.

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# AN EVALUATION OF ACTIVATED METHYL METHACRYLATE DENTURE BASE MATERIALS

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EARLY interest in the self-curing acrylic resins was centered on their use as filling materials, and credit for initial investigation undoubtedly should be given to the field of operative dentistry.[6,8,10] As a sequence of this development, its possibilities in the field of prosthetics as a denture base material have gradually attracted increasing attention. However, up to the present time, its acceptance as a base material has been retarded by the lack of any proved advantages over the heat-cured materials.

The purpose of this study is to ascertain how closely the activated acrylic resins used as denture base materials compare in physical properties and practicability with the conventional heat-cured acrylic bases. If it may be assumed that certain physical properties are an indication of the degree of polymerization attained by the activated acrylic, then a comparative study of these properties with those of heat-cured acrylic should be of significance.

For the purpose of organization, this report is divided into two parts. The first part consists of a comparison of the hardness and flow properties and transverse strength of test samples of activated acrylic with samples of heat-cured acrylic. The second part is a report of findings pertaining to polymerizing temperatures and dimensional changes occurring in test dentures made of activated acrylic.

Many terms have been applied to the process of inducing polymerization by chemical activation. In the literature and on the labels of the manufacturers' products are found a variety of descriptive adjectives, such as "cold-curing," "isothermal polymerizing," "autopolymerizing," "self-curing," and others. Until one descriptive term has been accepted by the profession for universal use, we will continue to find these and even more grandiose adjectives being used by the profession and by the manufacturers. Throughout this paper the term "activated acrylic" will be used when speaking of methyl methacrylate resin, the polymerization of which is usually induced by the chemical action of a tertiary amine incorporated into the monomer.

With full realization that the word "acrylic" is correctly used only as an adjective, nevertheless it will be used freely in the following pages when referring to methyl methacrylate monomer and polymer. Just as the terms "x-ray" and

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"radiograph" are substituted for the more scholarly "roentgenograph," so has general usage made the word "acrylic" synonomous with methyl methacrylate resins.

## HISTORY AND REVIEW OF LITERATURE

A review of the literature reveals reports of experimentation in the spontaneous curing of acrylic resins as far back as 1943, but with not enough success to cause much optimism at the time. All experiments reported were in the search for a satisfactory use of the acrylic material as an enamel substitute in the restoration of carious and otherwise deformed teeth.

The most informative report was the FIAT final report No. 1185 by Blumenthal[8] in May, 1947. In May, 1948[10] Leader wrote on the subject of direct acrylic fillings. The same principles are involved in both reports: the addition of benzoyl peroxide to the powder to accelerate polymerization and the addition of a tertiary amine to the monomer to reduce the critical polymerization temperature.

Basically, there is no difference between the self-curing acrylics used as filling materials and those used as prosthetic base materials. They differ principally in color and in adjustments in the polymer in order to give the physical properties required. In heat-cured acrylics a peroxide catalyst is present in the polymer. The application of heat and pressure breaks the peroxide into free radicals which catalyze the monomer and cause it to polymerize. In self-curing acrylics there is a chemical activator in the monomer. Only tertiary aromatic and aliphatic amines have been found to decompose satisfactorily the peroxide catalyst.[12] When the monomer is mixed with the polymer, this activator, by chemical action, breaks the peroxide into free radicals without the necessity for heat or pressure. Thereafter, the peroxide catalyzes the monomer which proceeds to polymerize similarly to that of heat-cured material.

## MATERIALS STUDIED

Four manufacturers' products were purchased from a local dental supply house for use in this study. These products are listed in Table I. Manufacturers' instructions for their use vary considerably, except that the instructions for the use of two of the products are nearly identical. The directions of each manufacturer were followed as closely as possible, except that a standard proportion of powder and liquid was determined which would fulfill the requirements for all four products. This proportion was 2.4 Gm. of powder to each cubic centimeter of liquid. The volume of material used therefore was the only variable, the proportion being held constant.

Further standardization of technique was maintained for all materials in the following manner: Room temperatures were recorded daily and found to be within a 3° variation, from 73° to 76° F. Mixing jars and spatulas were chilled to 66° F. All flasks for processing samples were placed in an oven at 100° F.

for a period of time prior to packing in order to maintain a reasonably constant flask temperature. A closing force of 4,000 pounds, which was found to be more than adequate to effect complete closure, was used on all flasks.

TABLE I. PRODUCTS STUDIED

| BRAND | ACRYLIC NO. | SAMPLE DESIGNATION | DISTRIBUTOR | LOCATION |
|---|---|---|---|---|
| Coldpac | 1 | C | Motloid Company, Inc. | Chicago, Ill. |
| NuSet | 2 | N | J. Yates Dental Mfg. Co. | Chicago, Ill. |
| Acralite 88 | 3 | A | Acralite Company, Inc. | New York, N. Y. |
| Duz-All | 4 | D | Coralite Dental Products Co. | Chicago, Ill. |

## HARDNESS PROPERTIES

The study of hardness of the activated acrylics was undertaken to see how the materials compared with the heat-cured acrylics with respect to this basic property.

Three samples of heat-cured methyl methacrylate, each machined into a blank 65 by 10 by 2.5 mm., were used as a standard specimen size for these tests. It was felt that if the values for these three samples were found to be equivalent, they could be taken as the standard value for conventional heat-cured methyl methacrylate. The Rockwell Superficial Hardness Tester, with a half-inch ball, a 30 kg. load, and with fifteen-second loading and recovery periods, was used to determine the hardness values for each of the three control specimens by taking the average of five readings for each. These were found to be quite constant; therefore a hardness value of 95.4 was taken as the standard value for heat-cured methyl methacrylate and used for comparison throughout the hardness tests. All values given are the average of five readings to the nearest tenth, but they are reported in the following tables to the nearest whole number.

TABLE II. ROCKWELL SUPERFICIAL HARDNESS (DRY SPECIMENS, 65 BY 10 BY 2.5 MM.)

| SPECIMEN | ELASPED TIME FROM DEFLASKING | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 HR. | DAYS | | | | | |
| | | 1 | 2 | 3 | 15 | 30 | 60 |
| Activated Acrylic No. 1 C–3A | 79 | 86 | 88 | 89 | 91.5 | 92.5 | 92.5 |
| Activated Acrylic No. 2 N–1A | 82 | 92 | 93.5 | 94 | 95 | 95 | 95 |
| Activated Acrylic No. 3 A–1A | 85 | 90 | 91 | 92 | 93 | 93 | 93 |
| Activated Acrylic No. 4 D–1A | 77 | 87 | 88 | 90 | 92 | 92 | 92 |

Denture flasks were prepared to process two oversize rectangular samples, which, when trimmed by the aid of a machined jig, would be approximately 65 by 10 by 2.5 mm. in size. Within an hour after deflasking, the blanks were trimmed to size and labeled. One blank was immersed in a beaker of water at room temperature, and the other was stored dry.

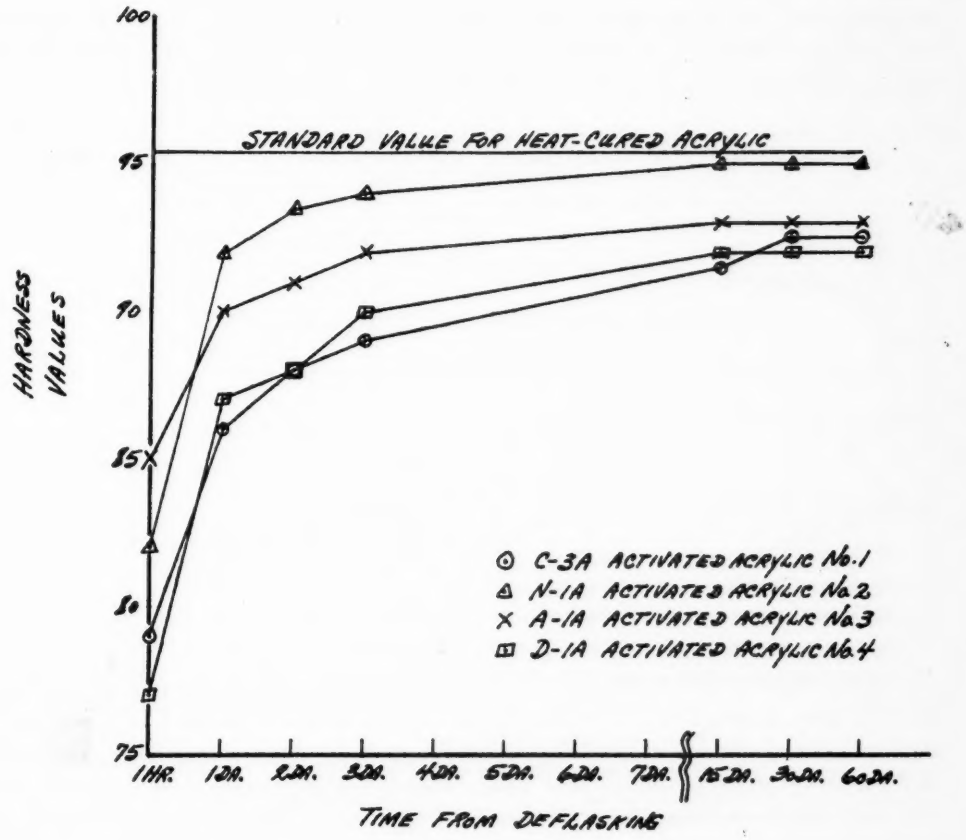


Fig. 1.—A comparison of the hardness of four products.

Hardness values were determined at one hour, twenty-four hours, and subsequent intervals. As shown in Table II and on the accompanying graph, Fig. 1, the hardness values at one hour varied from 77 to 86 for different products. In twenty-four hours all values increased considerably, the lowest being 85 and the highest 92, only 3.4 points less than the standard value for heat-cured acrylic. From twenty-four to forty-eight hours the values continued to increase for all dry specimens, but increased very slightly beyond the third day.

A variation between the four products is noticeable. One product (No. 2) at fifteen days had a hardness value of 95, which may be considered to be practically equal to that of the heat-cured material. The other three materials at this period were 91.5, 92, and 93.

These values were for specimens stored dry. It may be of significance to note that the companion samples, which were kept immersed in water at room temperature from the first hour, showed consistently lower hardness values than those which were kept dry.

It has been suggested that perhaps a short period of boiling following the bench cure might improve the physical properties of activated acrylic. Therefore, samples were prepared which were allowed to remain in the press for the full two and one-half hours as before and then were immersed for fifteen minutes in boiling water and bench cooled before deflasking and trimming to size.

TABLE III. HARDNESS. EFFECT OF FOLLOWING RECOMMENDED BENCH CURE WITH 15 MINUTES IMMERSION IN BOILING WATER BEFORE DEFLASKING (WET AND DRY SPECIMENS 65 BY 10 BY 2.5 MM.)

| SPECIMEN | ELAPSED TIME FROM DEFLASKING | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 HR. | DAYS | | | | | |
| | | 1 | 2 | 4 | 15 | 30 | 60 |
| Activated Acrylic No. 1 | | | | | | | |
| C–2A (dry) | 92 | 94 | 94 | 94 | 94 | 94 | 94 |
| C–2B (wet) | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| Activated Acrylic No. 2 | | | | | | | |
| N–3A (dry) | 93 | 94 | 94 | 94 | 94 | 95 | 95 |
| N–3B (wet) | 93 | 93 | 93 | 93 | 93 | 93 | 93 |
| Activated Acrylic No. 3 | | | | | | | |
| A–2A (dry) | 93 | 94 | 94 | 95 | 95 | 95 | 95 |

The effect of the additional 15 minutes' boiling may be seen in Table III, and on the accompanying graphs, Figs. 2, 3, and 4. Activated acrylic No. 1 showed a hardness value of 92 at one hour compared to a value of 79 at one hour for the same material when only bench cured. After twenty-four hours it was 94, and there was no further increase in hardness. This is a higher value at the end of twenty-four hours than the bench-cured sample had at the end of sixty days. Activated acrylic No. 2 had a hardness value of 93 at one hour compared to a value of 82 for bench cure alone. However, it is apparent that the ultimate hardness at thirty days was the same for both the bench-cured and the boiled samples. Activated acrylic No. 3 had a hardness value of 93 at one hour compared to a value of 85 for bench cure alone. At twenty-four hours it was 94 compared to 90 for bench cure alone and at fifteen days 95 compared to 92 for bench cure alone.

It should be noted that a comparison of wet and dry specimens, both treated by 15 minutes' boiling, showed lower hardness values for the samples immersed in water at room temperature than for those which were stored dry.

The effect of storing specimens in water at 37° F. was also determined. Two specimens were processed without boiling (activated acrylics No. 1 and No. 2) and immediately following the initial hardness readings at one hour were placed

in water at a constant 37° F. Hardness values were determined at the end of one, two, four, and eight days. Both products exhibited slightly higher hardness values at corresponding intervals than did the same product stored at room temperature.

### SUMMARY OF RESULTS ON HARDNESS TESTS

The four activated acrylic resins tested exhibited differences in hardness properties, but all four increased in hardness during the first fifteen days. After fifteen days the activated acrylics were nearly as hard as the conventional heat-cured acrylic.

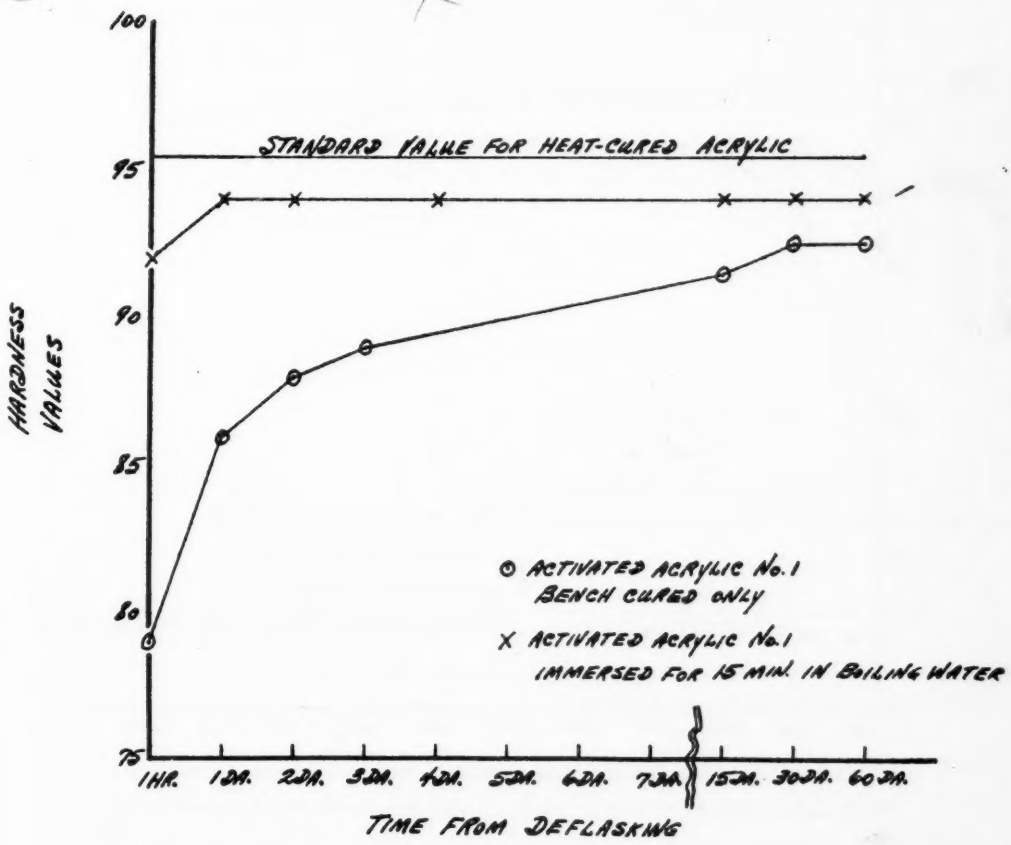


Fig. 2.—Hardness of activated acrylic No. 1 with bench cure only and after boiling.

Activated acrylics, which were kept immersed in water at room temperature from the first hour on, were consistently less hard than those stored dry, but those which were kept immersed in water at mouth temperature from the first hour had hardness values which were practically as high as those stored dry.

Immersion of the flask in boiling water for fifteen minutes after bench curing improves immediate hardness properties, but activated acrylic which is not sub-

jected to boiling will ultimately attain about the same degree of hardness as conventional heat-cured acrylic.

## FLOW PROPERTIES

Flow, as referred to in this study, was determined by the penetration in microns of a half-inch ball in the Rockwell Superficial Hardness Tester under a 30 kg. load, with readings taken fifteen seconds after the application of the major load. As in reporting hardness, the average of five readings to the nearest tenth was recorded, but all figures herein are given to the nearest whole number.

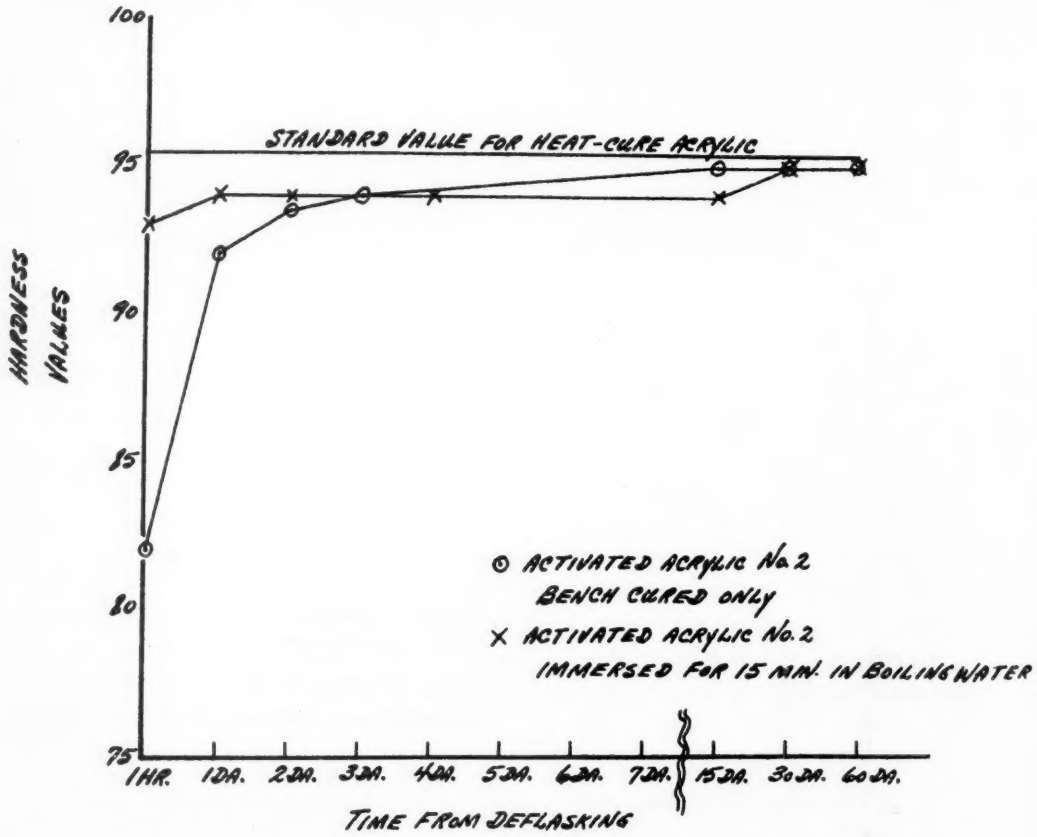


Fig. 3.—Hardness of activated acrylic No. 2 with bench cure only and after boiling.

Although all tests for determining flow were made at the same time and on the same samples as for hardness, it was necessary that these values be tabulated and considered separately, since hardness involves the recovery properties of a material, while flow does not.

Flow values for the three control specimens were determined by the average of five readings for each. A flow value of 79 was established as a standard value for heat-cured methyl methacrylate and used for comparison throughout the flow tests.

The same samples were used, and all readings for penetration were made at the same time as those for hardness. Table IV shows that at one hour after deflasking, flow values varied from 120 to 97. In twenty-four hours, all values had decreased, the highest being 102 and the lowest being 88. From twenty-four to forty-eight hours, the flow decreased and continued to decrease gradually through a thirty-day period. This may also be seen on the corresponding graph, Fig. 5.

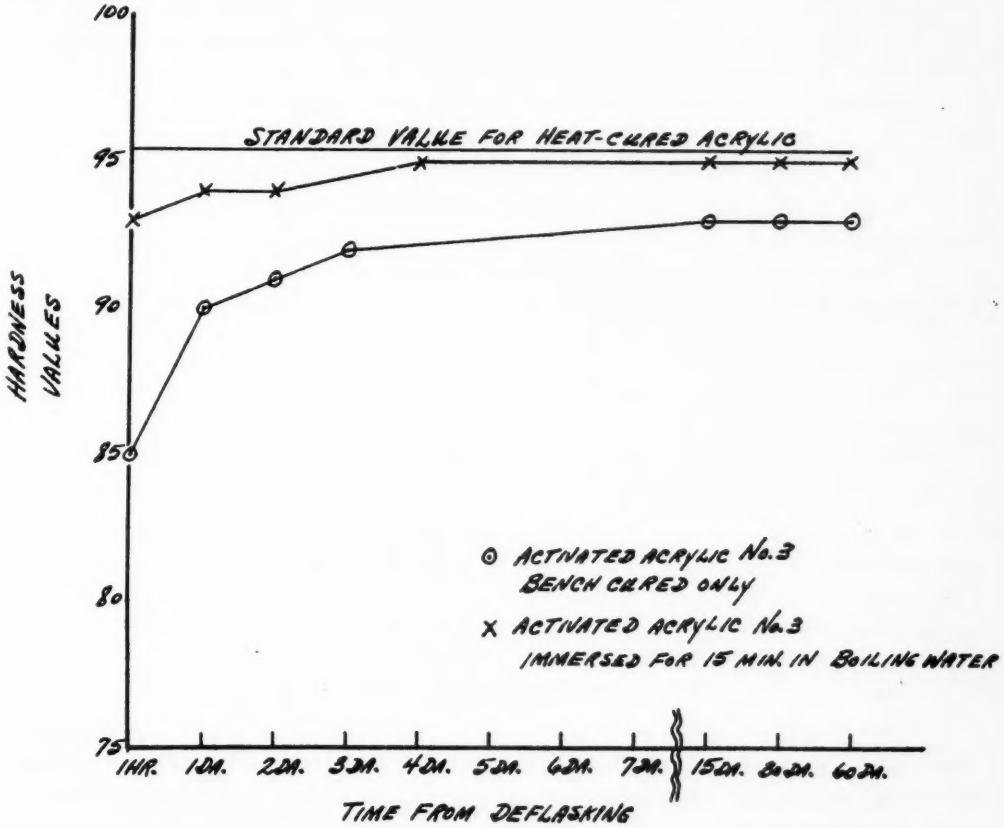


Fig. 4.—Hardness of activated acrylic No. 3 with bench cure only and after boiling.

A variation between the four products is apparent at any time interval. The lowest flow value is for activated acrylic No. 2 which reached 82 at fifteen days, only three points above the value for conventional heat-cured acrylic. The lowest values for the other three products at this period were 91, 85, and 95.

As was noted in comparing hardness values, the flow values for the companion samples which were stored in water at room temperature from the first hour were consistently less favorable.

Samples prepared by boiling for fifteen minutes, following a two and one-half hour bench cure, showed a greatly reduced flow at the end of the first hour. Activated acrylics No. 1 and No. 3 seem to have slightly improved flow properties as a result of the fifteen minutes' boiling, even after thirty and sixty days.

Activated acrylic No. 2 also showed less flow at one hour, 85 for the boiled specimen compared to 105 for bench cure alone. At fifteen days, however, the values were the same, as shown on the graph in Fig. 6. This indicates, as in the hardness tests, that with this material the additional 15 minutes' boiling resulted in immediate improvement in properties, but at the end of fifteen days or less the hardness and flow properties were practically the same as for bench cure alone.

TABLE IV. FLOW. (DRY SPECIMENS, 65 BY 10 BY 2.5 MM.)

| SPECIMEN | ELAPSED TIME FROM DEFLASKING | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 HR. | DAYS | | | | | |
| | | 1 | 2 | 3 | 15 | 30 | 60 |
| Activated Acrylic No. 1 C–3A | 115 | 108 | 98 | 94 | 91 | 91 | 91 |
| Activated Acrylic No. 2 N–1A | 105 | 88 | 84 | 83 | 82 | 82 | 82 |
| Activated Acrylic No. 3 A–1A | 97 | 90 | 88 | 86 | 85 | 84 | 84 |
| Activated Acrylic No. 4 D–1A | 120 | 102 | 101 | 99 | 95 | 94 | 94 |

As in the hardness tests, flow values for the samples kept immersed in water at room temperature varied more from the standard value than those which were stored dry. Storing specimens in water at a constant mouth temperature resulted in lower flow values than storing samples in water at room temperature.

### SUMMARY OF RESULTS ON FLOW TESTS

Flow values for the four products tested varied over a much wider range than did their hardness values, and, although flow decreased steadily over a fifteen-day period and then leveled off, two of the materials tested still exhibited more flow than did the conventional heat-cured acrylic.

Flow values for the acrylic samples stored in water at room temperature were consistently higher than those samples kept dry. Flow values were lower for the samples kept in water at mouth temperature from the first hour.

Immersion of the flask in boiling water for fifteen minutes after bench curing improved flow properties to a varying degree with the three products tested. Activated acrylic No. 3 seemed to benefit the most by boiling, whereas activated acrylic No. 2 benefited only initially, and after two days the flow values were the same whether boiled or not.

### TRANSVERSE STRENGTH

Tests for transverse strength were conducted on all specimens; an instrument as described in the National Bureau of Standards, Circular C433,[8] was used. In

preparation of samples for transverse testing, a variation in cross-sectional dimensions was observed and this variation compensated for. Three control specimens of conventional heat-cured methyl methacrylate were first tested, and an average deflection of 1.49 mm. was accepted as a standard for comparison for specimens 65 by 10 by 2.5 mm., between loads of 1,500 and 3,000 Gm. The deflection in millimeters for all specimens is given in Table V. The results of tests for transverse strength may be summarized as follows:

All the activated acrylic samples which were kept dry exhibited less transverse strength than the three samples of conventional heat-cured acrylic which had also been kept dry. All the activated acrylic samples which had been stored in water had more transverse strength than their dry companion specimens.

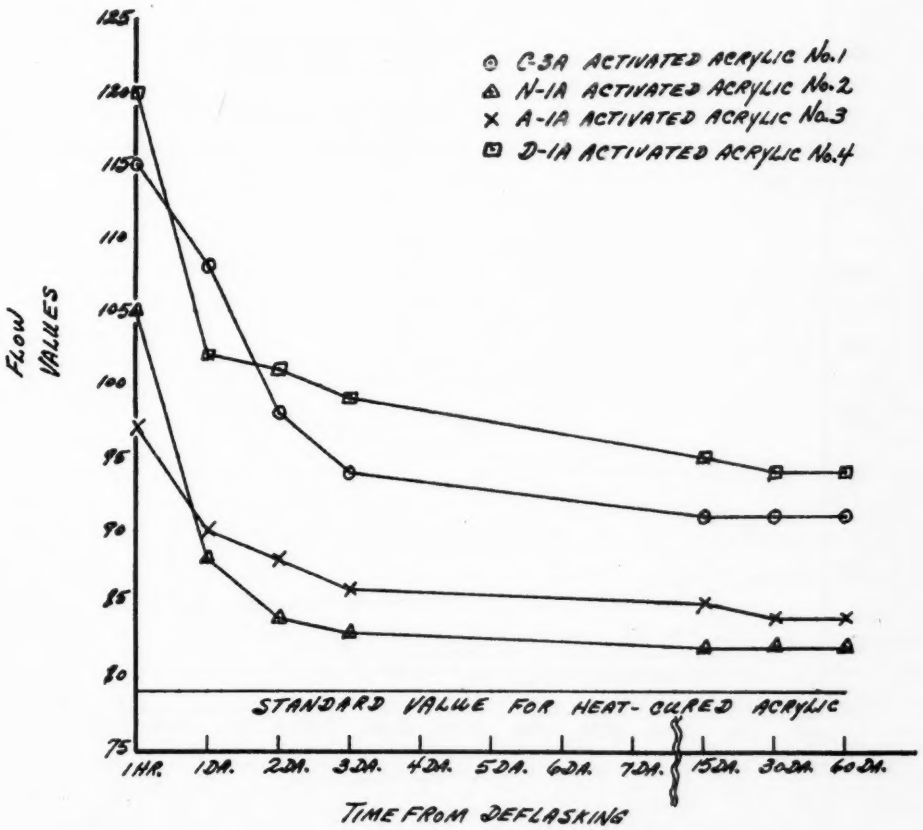


Fig. 5.—A comparison of the flow properties of four products.

A correlation exists between transverse strength and hardness and flow properties in regard to those activated acrylics which seemed to benefit from immersion for fifteen minutes in boiling water. Activated acrylics No. 1 and No. 3 seemed to be stronger as a result of boiling, but activated acrylic No. 2 exhibited the same transverse strength by bench cure as by boiling.

POLYMERIZING TEMPERATURES

Inasmuch as the tertiary amine actually does lower the critical polymerization temperature, the temperature at which polymerization begins may be quite low. This would be at that point at which an exothermic temperature rise begins. In an attempt to record the actual temperature rise within the denture flask, thermocouples were inserted within test dentures. Two thermocouple wires were inserted through the two holes in the top of the Hanau flask and attached to a waxed-up denture. The top half was then poured and the wax eliminated, leaving the thermocouples exposed. One thermocouple was imbedded in the center of the palate and one in the buccal flange opposite the second molar.

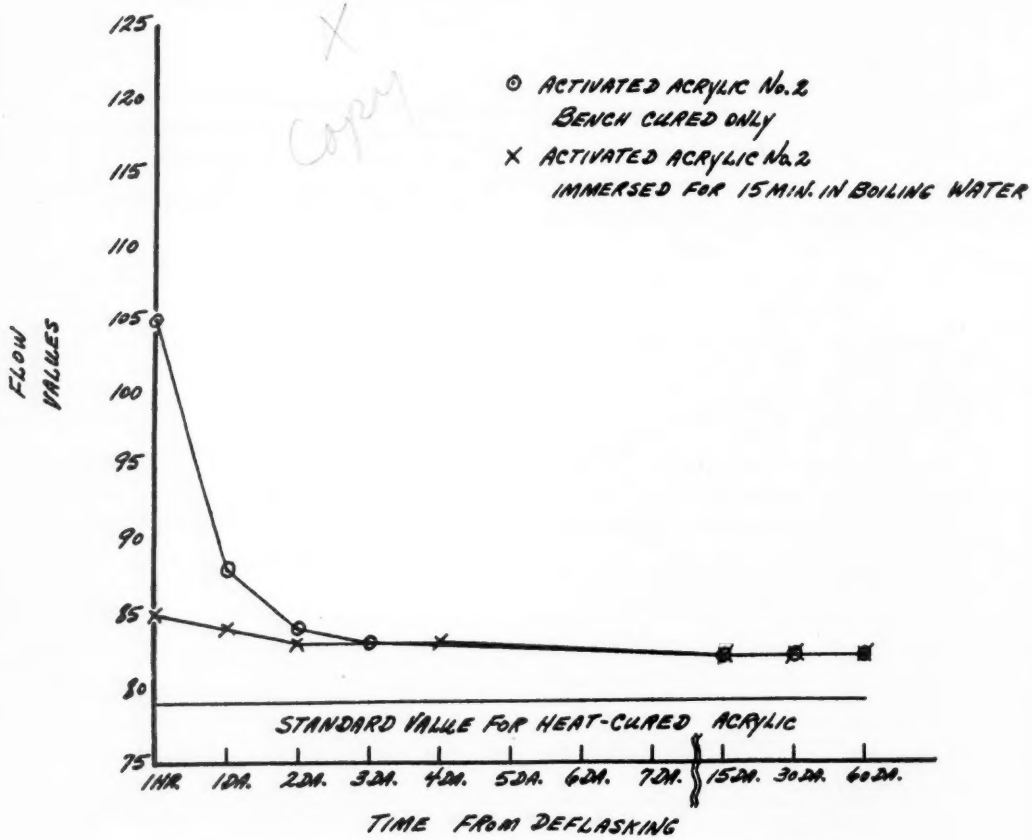


Fig. 6.—Flow of activated acrylic No. 2 with bench cure only and after boiling.

Three upper dentures and one lower denture were thus prepared and processed, but space will permit only a summary of results and the inclusion of one such temperature chart thus obtained (Fig. 7). The highest temperature recorded was in upper denture No. 3, with activated acrylic No. 3 packed into a warm (120° F.) flask. A temperature peak of 153° F. was recorded in the buccal flange area only twelve minutes after the powder and liquid were mixed, the acceleration

and higher temperature being due to the fact that the flask was warm when filled. The thinner palatal portion attained a temperature of 131° F. 13 minutes, 15 seconds after mixing.

TABLE V. TRANSVERSE STRENTH

| SPECIMEN | DEFLECTION BETWEEN LOADS OF 1,500 AND 3,000 GM. (MM.) |
|---|---|
| Control No. 1 | 1.50 |
| Control No. 2 | 1.53 |
| Control No. 3 | 1.45 |
| Activated Acrylic No. 1 | |
| C–3A (dry) | 1.94 |
| C–3B (wet) | 1.75 |
| C–2A (dry) (boiled 15 minutes) | 2.19 |
| C–2B (wet) (boiled 15 minutes) | 1.33 |
| Activated Acrylic No. 2 | |
| N–1A (dry) | 1.84 |
| N–1B (wet) | 1.34 |
| N–3A (dry) (boiled 15 minutes) | 1.83 |
| N–3B (wet) (boiled 15 minutes) | 1.40 |
| Activated Acrylic No. 3 | |
| A–1A (dry) | 2.02 |
| A–1B (wet) | 1.95 |
| A–2B (dry) (boiled 15 minutes) | 1.62 |
| Activated Acrylic No. 4 | |
| D–1A (dry) | 2.28 |
| D–1B (wet) | 1.63 |

It is felt that these temperatures are not significant in relation to how completely the polymerization is affected by the exothermic reaction. The temperatures recorded merely show the highest temperatures attained within a section of a denture, due to the exothermic reaction of the polymerizing material, as influenced by variable factors.

Reaction time and reaction temperatures are both influenced by the temperature of the flask. A flask cooled to 75° F. is better than one still warm to the touch and will result in slower reaction time and, therefore, more time for packing the denture.

Thinner portions of the denture will exhibit lower exothermic temperatures, as they would if made with conventional heat-cured acrylic. This need not be considered a factor in the degree of polymerization, however, any more than with heat-cured acrylic.

## DIMENSIONAL CHANGES IN TEST DENTURES

The same dentures which were used to record exothermic temperatures were prepared so that they could be accurately measured for the purpose of determining dimensional changes during and after processing. Various methods have been

used for measuring linear change across the posterior end of a denture. Admittedly, the measuring of linear change across a curved palatal surface may be less accurate than measuring a straight sample of material, but any standardized method that permits comparison should be acceptable. The method used in this study was similar to methods previously used in measuring heat-cured acrylic dentures.

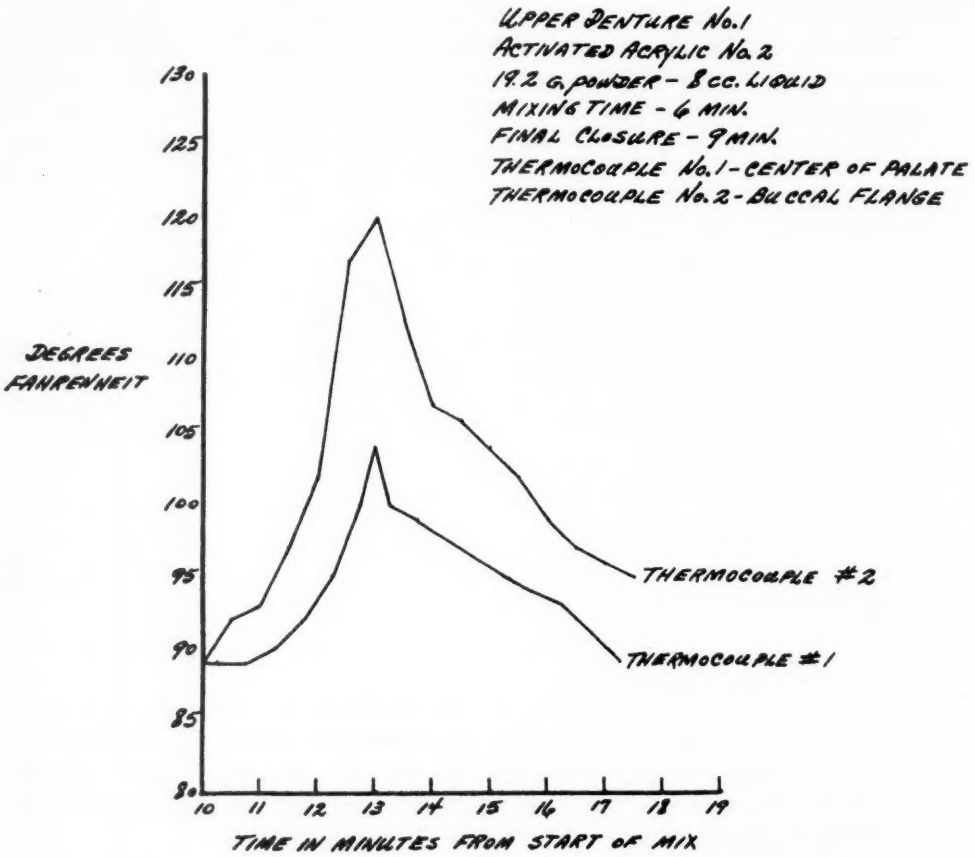


Fig. 7.—Polymerizing temperatures as recorded by thermocouples.

Small, machined, threaded studs were prepared from 8-32 brass machine screws and imbedded to one-half their length in the wax pattern of an upper denture at the distal end of the ridge on either side. A fine cross was engraved in the exposed end of the studs. The wax denture and cast, invested in the lower one-half of the flask, were then placed under the comparator microscope, and the distance between the two studs was measured. The upper one-half of the flask was then poured, and the denture was processed. After processing, the denture, still on its cast, was again measured, and the dimensional change during processing was recorded.

Three upper dentures were treated in this manner, and the curing shrinkage was computed for each. As may be seen in Table VI, this was less than may

be expected from conventional heat-cured acrylic. The greatest shrinkage was exhibited by the denture which was purposely processed with a higher proportion of activated monomer than the other two, a computed shrinkage of 0.24 per cent, compared to 0.14 per cent for the same material mixed in the proportion of 2.4 Gm. per cubic centimeter. Denture No. 3 processed in activated acrylic No. 3 in the same proportion exhibited a shrinkage computed at 0.102 per cent.

TABLE VI.

| | MM. |
|---|---|
| Upper Denture No. 1 | |
| (Activated acrylic No. 2 8 c.c./19.2 Gm.) | |
| Measurement before investing | 42.85 |
| Measurement after processing | 42.79 |
| Linear curing shrinkage | 0.14% |
| After 48 hours in water | 42.76 |
| After 5 days in water | 42.78 |
| After removal from model | 42.774 |
| After immersion 15 minutes in water at 150°F. and cooling | 42.774 |
| After immersion 15 minutes in water at 200°F. and cooling | 42.804 |
| Upper Denture No. 2 | |
| (Activated acrylic No. 2 9 c.c./19.2 Gm.) | |
| Measurement before investing | 41.68 |
| Measurement after processing | 41.58 |
| Linear curing shrinkage | 0.24% |
| After 48 hours in water | 41.57 |
| After 5 days in water | 41.69 |
| Upper Denture No. 3 | |
| (Activated acrylic No. 3 8 c.c./19.2 Gm.) | |
| Measurement before investing | 48.94 |
| Measurement after processing | 48.89 |
| Linear curing shrinkage | 0.102% |
| After 5 days in water | 48.95 |
| After removal from model | 48.95 |

It is generally accepted that higher-than-mouth temperatures may bring about a distortion of conventional heat-cured acrylic by causing a release of internal strains. To determine whether or not an activated acrylic denture base could be subjected to higher temperatures without distortion, upper denture No. 1 was immersed for fifteen minutes in water at 150° F. and then left in the water bath overnight to return to room temperature. The last measurement of the denture before subjecting it to the hot water was 42.774 mm., and after its return to room temperature, the distance was found to be unchanged. This would seem to indicate that no distortion or dimensional change had occurred.

The same denture was again immersed in a water bath for fifteen minutes, this time at 200° F., and again measured after its return to room temperature. The distance was found to be slightly greater, 42.804 mm., showing that a dimensional change of 0.3 mm. or 0.72 per cent had occurred during immersion in the 200° water. At this higher temperature, this distortion may have been due to a thermoplastic flow. It would seem safe to say that internal strains were not present in

this denture which could be released by subjecting it to unusually high water temperatures and that a patient could safely wash the denture at normal bathroom temperatures without distortion.

## CONCLUSIONS

1. A comparison of the hardness and flow properties of the activated acrylics and heat-cured acrylic samples seems to indicate that some of the activated acrylics are less completely polymerized than conventional heat-cured acrylic. At least one of the products tested, however, compared favorably with heat-cured acrylic in these two respects and also in the transverse strength of comparative test samples.

2. Subjecting the activated acrylics to immersion in boiling water for fifteen minutes following the bench cure improves the immedate physical properties, indicating a more complete polymerization than by bench cure alone, at the time of deflasking. Without boiling, polymerization evidently continues over a period of several days, until at the end of fifteen days or less the activated acrylics are nearly as completely polymerized as conventional heat-cured acrylic. Therefore, little seems to be gained by the additional fifteen minutes of boiling.

3. Under identical working conditions of temperature, with accurately measured proportions of powder and liquid, an activated acrylic resin will react in a predictable manner in regard to available working time. Working time will vary with each manufacturer's product, however, and it must be ascertained by the operator. A standard operating procedure must be adopted for the material being used.

4. Results of an attempt to measure accurately the dimensional changes across the posterior end of test upper dentures seem to indicate that less curing shrinkage occurs during the polymerization of activated acrylic denture base materials than with conventional heat-cured resins. However, further investigation and comparison of the two materials are indicated.

5. There is reason to believe that because of the principles involved in the curing of methyl methacrylate at lower temperatures a denture base is produced that is relatively free of internal strain, and therefore it may be more accurate as a denture base material.

## REFERENCES

1. Sweeney, W. T.: Denture Base Material: Acrylic Resins, J. A. D. A. **26**:1863-73, 1939.
2. Sweeney, W. T., Paffenbarger, G. C., and Beall, J. R.: Acrylic Resins for Dentures, J. A. D. A. **29**:7-33, 1942.
3. Souder, W., and Paffenbarger, G. C.: Physical Properties of Denture Materials, Circular of the National Bureau of Standards C433, Feb. 6, 1942.
4. Peyton, F. A., and Mann, W. R.: Acrylic and Acrylic-Styrene Resins: Their Properties in Relation to Their Uses as Restorative Materials, J. A. D. A. **29**:1852-64, 1942.
5. Peyton, F. A.: Physical and Chemical Characteristics of Synthetic Resins Used in Dentistry, J. A. D. A. **30**:1179-89, 1943.
6. Tanabaum, N.: Direct Polyacrylic Restorations, Tufts D. Outlook **20**:24-27, 1946.
7. Tylman, S. D., and Peyton, F. A.: Acrylic and Other Synthetic Resins Used in Dentistry, Philadelphia, 1946, J. B. Lippincott Company.

8. Blumenthal, L. M.: Recent German Developments in the Field of Dental Resins, FIAT final report No. 1185, May 27, 1947.
9. Skinner, E. W.: The Science of Dental Materials, ed. 2, Philadelphia, 1946, W. B. Saunders Company.
10. Leader, S. A.: Direct Acrylic Fillings, Brit. D. J. **34**:214-215, 1948.
11. Peyton, F. A.: Notes From American Academy for Plastic Research in Dentistry, tenth annual meeting, Feb. 4, 1950.
12. Taylor, P. B., and Frank, S. L.: Low Temperature Polymerization of Acrylic Resins, J. Dent. Research **29**:486-492, 1950.
13. Wolcott, R. B., Paffenbarger, G. C., and Schoonover, I. C.: Direct Resinous Filling Materials: Temperature Rise During Polymerization, J. A. D. A. **42**:253-263, 1951.

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# PRECISION ATTACHMENT DENTURES

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FROM their first introduction to the dental profession, precision attachments have been surrounded by an aura of mystery, implying that great skill is required in their successful use. This has served as a contributing factor in discouraging their general use. From the patient's viewpoint, a precision attachment appliance offers more comfort and security than a corresponding appliance with clasps, with an obvious advantage in esthetic appearance.

Schuyler[1] has stated in connection with precision attachments: "No other type of retention permits a more favorable distribution of functional stresses, both vertical and horizontal." In a discussion of horizontal forces, he further stated: "No combination of clasp and lug can more favorably distribute these stresses than does the precision attachment."

Granger,[2] in discussing the tipping of an abutment tooth as a result of the simple type of occlusal rest usually employed in clasp appliances, showed that the precision attachment prevents this tipping, as the thrust of the occlusal end of the male portion forces the tooth to maintain its position.

Consideration of the replacement of missing teeth should also include a complete evaluation of the entire masticatory apparatus. With the loss of teeth, there result, to a greater or lesser degree, disturbances of the remaining dental structures. Drifting, tilting, rotation and extrusion of teeth, food impactions, pocket formation, and occlusal trauma are some of the conditions requiring attention, regardless of the method of tooth replacement. Upon these weakened structures is now imposed the added burden of a partial denture. It is therefore of the utmost importance to construct an appliance which will reduce and distribute occlusal and lateral stresses in the broadest possible sense. This is necessary to prevent overstimulation and destruction of the tissues supporting the appliance.

The application of desirable principles in the construction of a precision attachment appliance can be divided into three phases: (1) abutment planning, (2) saddle design, and (3) relationship of saddles to abutments.

## ABUTMENT PLANNING

In a consideration of abutment planning, the full cast gold crown, with an acrylic veneer where necessary, plays a major role. In conjunction with a removable precision appliance, the construction of fixed bridges wherever possible and with full crown coverage has many advantages. In addition to the excellent features that the full crown provides in the way of retention and caries protection, it also allows for corrections of contact, contour, occlusion, and some modification of tooth position. Reduction in the width of the occlusal surfaces and correction

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of occlusal disharmony can greatly modify the stresses placed on teeth in function and help them to sustain the stresses of an appliance.

In the case of a lower unilateral distal extension appliance, where the tooth-borne side presents the picture shown in Fig. 1, it would be virtually impossible to prepare the molar to receive properly a precision attachment because of its excessive mesial inclination. Fig. 2 shows the construction of a fixed bridge with the attachment placed in the lingual aspect of the pontic. This obviates the necessity of deep preparation within the teeth for the reception of attachments. The pontic can also accommodate a wider and longer attachment than either bridge abutment. This assumes added importance when the abutment teeth are very short. The difficulty in removing the appliance is eliminated by the construction of an arm that originates from the upright of the appliance, is recessed across the occlusal of the pontic, and ends in a short buccal stud. Another advantage of constructing a fixed bridge is that a maximum splinting effect is achieved. This effect can be supplemented, where necessary, by crowning and splinting additional teeth mesial to the bridge.

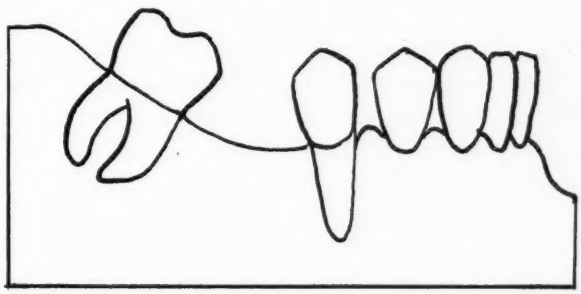

Fig. 1.—Excessive mesial inclination of the molar makes it virtually impossible to receive properly a precision attachment.

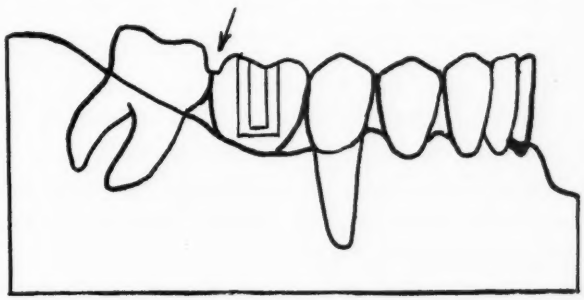

Fig. 2.—A fixed bridge has been constructed with the female attachment placed in the lingual aspect of the pontic. The arrow points to a groove in which the arm used to remove the appliance is recessed.

In conjunction with a precision attachment appliance, the construction of fixed bridges replacing missing anterior teeth provides two additional advantages. First, where it is not prohibited by a close bite, the anterior pontic can receive a large attachment in its lingual aspect, thus eliminating overcontouring of the individual abutment crown and use of a relatively small attachment. The anterior pontic may also be constructed as a cantilever, projecting distally from two or more

splinted anterior teeth. Second, in cases where missing anterior teeth are included in a removable precision appliance which has its attachments located posteriorly to the missing anterior teeth, there results an unfavorable leverage action during incision which tends to lift the distal portions of the saddle areas away from the tissues.

In distal extension appliances, the abutment teeth are placed under strain and require special attention. In order to provide a sufficiently high safety factor in this area, it is always better to splint two or more teeth together. The splinting of teeth in this fashion increases their strength in geometric proportion and permits overcontouring for the purpose of receiving the attachment as an alternative to deeply recessing the attachment into the abutment tooth.

To summarize the theme of abutment planning, a wide distribution of stress is accomplished by means of fixed bridges and multiple splinting, wherever possible by full crown coverage with acrylic veneers as indicated.

## SADDLE DESIGN

The second phase in the construction of a precision attachment appliance involves a discussion of the saddle areas. The maximum denture-bearing area should be utilized, and the denture borders should be of sufficient thickness and well rounded. Palatal bar connectors offer greater comfort, stability, and distribution of stress as they approach full palate coverage.

There is a considerable difference of opinion regarding the most effective method for making the impressions of the saddle areas. One school of thought believes that the tissues should be recorded in their functional state and the impression made under occlusal stress. The opposing school believes that the tissues should be recorded in their passive or anatomic shape. Regarding the latter school, it is reasonable to assume that a mucostatic type of impression can be achieved.

There are a number of questions to be answered regarding the functional type of impression.

1. Do the impression material used and the amount of pressure applied achieve the desired functional distortion of the tissues?

2. Is it advisable to reproduce this "functionally" distorted tissue surface on the denture base in the hope that the tissues will distort in exactly the same fashion under varying functional conditions?

3. Assuming that there is a difference in tissue form between the functional and anatomic (rest) states, is there any trauma produced by the initial impingement of a functionally surfaced denture saddle against the tissues at rest?

There is reason to believe that, when intimate apposition exists between the tissue surface at rest and the denture base, the tissue is held in this position even under functional stress, since the denture base tends to inhibit tissue distortion.

To summarize, the denture saddle should be a faithful reproduction of the maximum denture-bearing area, taken with the tissues in their passive state.

## RELATION OF THE SADDLES TO THE ABUTMENTS

The third phase to be considered is the relationship of the saddles to the abutments, both at rest and during occlusal stress.

With precision attachments, the relationship of the saddles to the abutment teeth is maintained in an exact manner, and it is necessary to establish this relationship accurately. Fig. 3 shows, to an exaggerated degree, the difference in saddle position in the rest position and in the functional or slightly depressed position. Since the functional position occurs during the stress of mastication, it is important to establish this position in relation to the abutment teeth in order to avoid unfavorable torsional effects. The return of the denture saddle to the rest position is caused by the resilient effect of the tissues. It is not deleterious to the abutment teeth, as the rotational force involved is comparatively small and in a more favorable mesial direction. This movement is accommodated by a slight elevation of the male attachment in its receptacle.

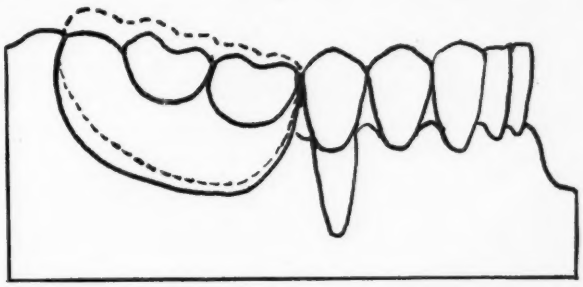

Fig. 3.—The functional position of the saddle is represented by the solid lines and the rest position by the dotted lines.

Briefly summarized, the preceding can be accomplished by making an accurate impression of the saddle areas at rest in an individual shimmed tray and then by exerting positive functional stress on this tray while a second impression is made which records the relationship of the abutment teeth to the first impression and to each other.

## IMPRESSION TECHNIQUE

The clinical procedure involves the construction of a rigid metal or acrylic tray which encompasses the denture-bearing areas and has an outline similar to that of the finished appliance. This tray is constructed with a suitable relief from the tissues in order to allow for a mucostatic type impression to be made with a free-flowing impression paste. This impression of the soft tissues is removed from the mouth when set, inspected, trimmed, and tested for stability. The second tray is a stock impression tray which has openings cut into it to allow the operator's fingers to be placed over the saddle areas of the first tray. With the mucostatic impression in place in the mouth, the second tray is used to take a plaster impression of the entire upper or lower jaw. The operator places his fingers through the aforementioned tray openings and exerts positive seating pressure against the first tray until the plaster is fully set. Gauze or tin foil can be used to prevent spilling of the plaster through the tray openings.

To facilitate the application of finger pressure through the tray openings, the first tray is constructed with ridges or knobs opposite these openings.

The question of stress breakers always arises at this point in the discussion. Schuyler[3] said: "Stress breakers are seldom indicated, and never those which permit all the occlusal stress to be placed on the saddle supporting tissue, or which permit excessive movement of the denture base." The impression method outlined tends to eliminate the use of stress breakers and helps maintain a stable result. However, in the last analysis, the dentist must consider each case carefully and study the biomechanics involved in arriving at a conclusion.

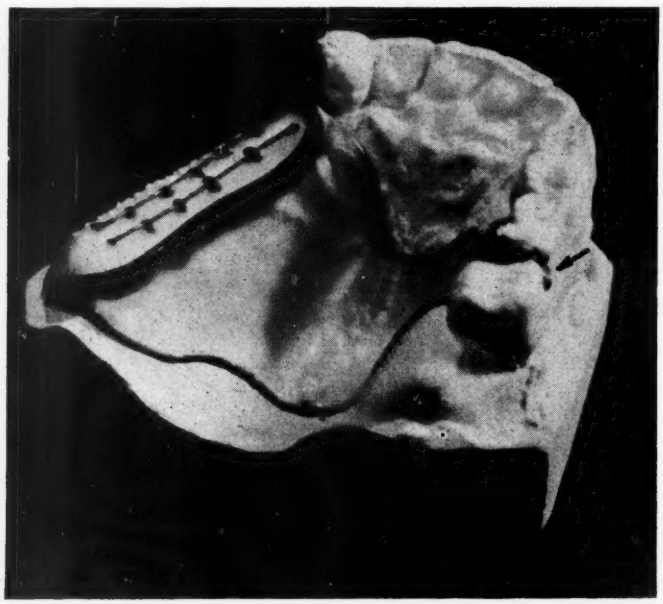

Fig. 4.—The refractory investment cast waxed up. The arrow points to the stud which will help in the removal of the appliance.

Figs. 4, 5, and 6 show an upper unilateral distal extension denture under construction. The left side has been restored by means of a fixed bridge, and the attachment is located in the molar pontic. On the right side the lateral incisor and cuspid have been splinted together with full crowns with veneer facings. Fig. 4 shows the denture waxed up on the refractory investment cast. The arrow points to the stud which will help the patient remove the denture from the mouth.

Fig. 5 shows how the saddle and abutments are held in place with dabs of plaster while the male attachments are being welded to the denture uprights at their occlusal ends without the use of solder. After the welding process is complete, the denture is removed, antiflux is applied to the male attachments, and the joints are soldered freehand in a small flame. This method provides unfailing accuracy and simplicity, as the case assembly is done directly on the master cast in a matter of minutes, without the use of sticky wax, plaster cores, or investment.

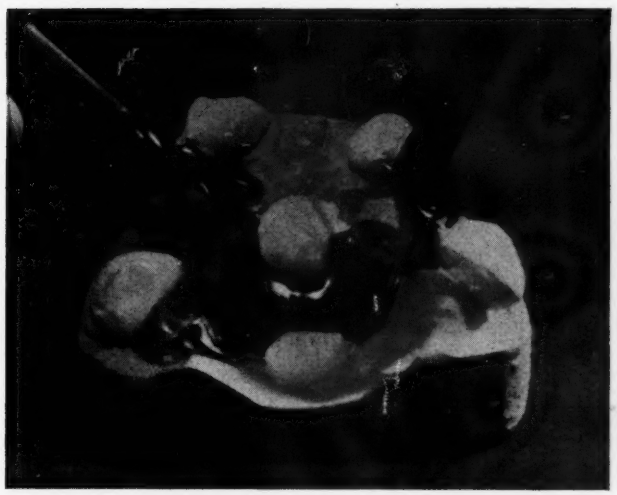

Fig. 5.—The saddle and abutments are held in place with dabs of plaster, while the male attachments are welded to the denture uprights. To prevent sparking at the carbon, the carbon is applied first and removed last. The brass electrode is used to make and break the circuit.

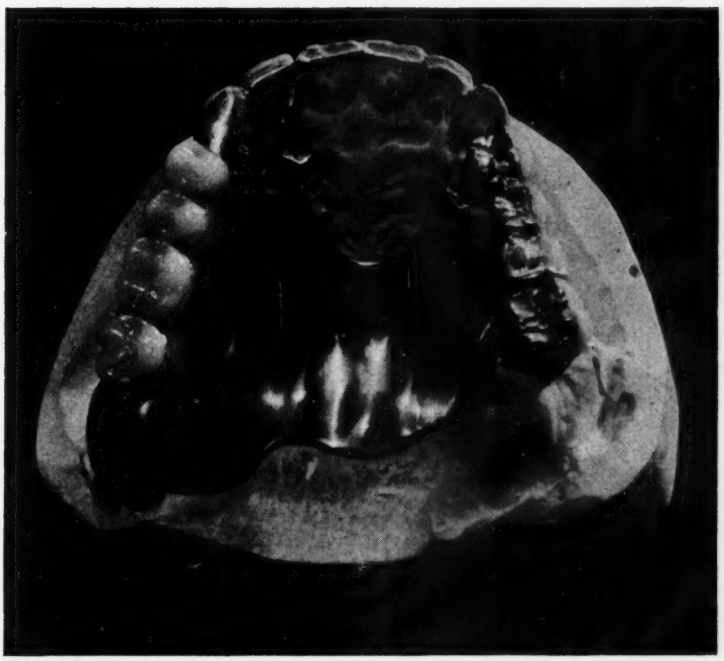

Fig. 6.—Denture waxed up and ready to be processed.

A practical consideration at this point involves the slight raising of the male attachment in its receptacle before the welding operation in order to provide an additional compensation for tissue resilience. This is desirable in nearly all cases, and the amount of relief under the male part of the attachment can be determined by a study of the tissue resiliency under the saddle areas. The actual relief can be accomplished by placing a desired thickness of sheet copper in the floor of the female part of the attachment. This thickness should be the same for all the attachments on a given appliance to allow for symmetrical movement during function. When the attachment is placed in the pontic of a fixed bridge, the same degree of relief must be provided under the arm that crosses the pontic. This is accomplished on the master cast before it is duplicated for casting.

Fig. 6 shows the denture waxed up and ready to be processed. The denture saddle is reproduced in gold so the case can be invested without using the master cast, which has low-fusing metal under the abutments. Another reason for casting the entire saddle area in gold is to maintain the established relationship between saddle areas and female attachments. This might be changed in the processing of an acrylic base. Experience has shown that the thin gold casting made over the saddle areas does not greatly affect the weight of the finished denture, as this area would normally require a series of gold loops or mesh for retention of the acrylic saddle. The loops can be fewer and finer when the gold base is present. This does not preclude the possibility of an acrylic rebase in later years, as retention can be provided by a series of holes drilled through the gold base.

The factor of short teeth is often mentioned as a contraindication for precision attachments. Quite often in such cases, the aid of the periodontist can be enlisted to lengthen the clinical crown and reduce pocket depth by conservative gingivectomy. If necessary, additional retention can be secured in these cases by the use of lingual clasp arms. The type of attachment most favorable in these cases is one which has leaves that open along the entire length of the male attachment, so that it will still maintain a spring action when it is shortened.

## SUMMARY

The construction of precision attachment dentures does not require an unusual degree of skill and is within the scope of the practitioner who can prepare teeth to receive full crowns and construct fixed bridges.

An adherence to the principle of broad distribution of stresses and the incorporation of a sufficient safety factor by the use of multiple splinting of teeth assure permanence of results.

Technical improvements affecting appliance construction are being made constantly. The assembly of the appliance directly on the master cast by means of the electric welder, followed by freehand soldering of the male attachments, has eliminated a tedious and uncertain operation.

## REFERENCES

1. Schuyler, Clyde H.: Partial Denture Design and Planning, in Miller, S. C.: Oral Diagnosis and Treatment, ed. 2, Philadelphia, 1946, The Blakiston Company, p. 461.
2. Granger, E. R.: Mechanical Principles Applied to Partial Denture Construction, J. A. D. A. **28**:1943-1951, 1941.
3. Schuyler, Clyde H.: Stress Distribution as the Prime Requisite to the Success of a Partial Denture, J. A. D. A. **20**:2149, 1933.

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# LOAD DISTRIBUTION IN EXTENSION SADDLE PARTIAL DENTURES

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THE METHOD used to make impressions of the supporting and retaining anatomic structures of the mouth is of basic importance for obtaining optimum distribution of the masticatory load in the construction of removable partial dentures, especially those of the lower extension saddle type. A partial denture constructed on a cast made from an impression which does not fulfill this requirement will be a failure regardless of how well designed and executed it might be.

Most authors on the subject of partial dentures have recognized this fact and have given it major consideration. McLean[1] stated: "The basic problem of partial denture stabilization is to equalize the resilient and nonresilient support." While there seem to be very few arguments concerning the truth of this statement, a multitude of methods have been suggested as a solution to this problem.

## FUNCTIONAL IMPRESSIONS

To obtain equalization between tooth and soft tissue support, McLean[1] and others suggested the taking of a so-called "functional impression." This means recording the mucosa in a compressed or displaced state by one impression and then relating it to the abutment teeth by means of a secondary impression. McLean suggested the use of impression cement in a tray provided with compound occlusion rims. The impression of the saddle areas was taken under biting stress and then assembled with the teeth by means of a colloid impression taken over all.

Cummer,[2] in 1928, described a technique known as the sectional compound impression technique. The saddle area was recorded by means of a primary compound impression; then a secondary compound impression of the teeth was made.

Applegate[3] proposed a method whereby the denture saddle, before processing, was rebased with waxes of varying consistencies and under biting stress.

Spreng,[4] of Switzerland, suggested the use of a technique known as the "chewing impression." Soft gutta-percha in a vulcanite tray was molded by chewing pressure and related to the partial denture metal frame by means of a plaster impression.

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The proponents of the so-called functional impressions put great emphasis on tissue compression in order to get a registration of the "functional ridge form." They used materials such as compound or wax, which, because of their heavier consistency, were supposed to displace the more elastic tissue parts of the edentulous area. They made a definite distinction between the surface or anatomic contour and the functional or compressed contour of the alveolar ridge. Their thought was to get tissue compression in order to place the load properly on the ridge and thereby to minimize cantilever action on the abutment teeth.

This functional ridge form, unlike the anatomic form, is not a definite, consistently recurring contour of the ridge. The functional ridge form varies, according to degree and direction of stress placed on it, as delivered by the type and consistency of the impression material used. The mucosa always tries to return to its normal anatomic and physiologic state and introduces forces under the saddle which are dislocating in nature. There are many who feel that what was previously thought of as tissue resiliency is nothing but the return action of the forcefully displaced ridge tissue to its passive rest position. The result will not be an increase, but rather a decrease, in saddle stability and an accelerated tissue resorption due to traumatic and improperly distributed stresses. These traumatic stresses upon the tissues in turn are due to the inability of the mucosa to maintain its anatomic form during function.

## ONE-PIECE IMPRESSION

Many dentists have been using plaster, hydrocolloid, or alginate as the material for a one-piece impression of both the teeth and the mucosa. They have, thereby, disregarded the difference in quality of support supplied by the various supporting structures.

The one-piece colloidal or plaster impression will produce a cast which cannot possibly represent a functional relationship between the various supporting structures of the mouth. All that may be obtained from such an impression is a cast of the hard and soft tissues at rest. With the partial denture in position in the dental arch, the occlusal rest will fit the rest seat of the abutment tooth, while the denture base will fit the surface of the mucosa at rest (Fig. 1). When a masticatory load is applied to the extension saddle, the rest will act as a definite stop, which will prevent the part of the saddle near the abutment tooth from transmitting the load to the underlying anatomic structures. The distal end of the saddle, however, being able to move freely, will transmit the full masticatory load (Fig. 2).

It is obvious that the soft tissues covering the alveolar bone cannot by themselves carry any load applied to them. They act as a protective padding for the bone which, in the final analysis, is the structure that receives and carries the masticatory load. Distribution of this load over a maximum area of bone is a prime requisite in preventing trauma.

In a partial denture constructed from a one-piece impression, the masticatory load will be carried only by the abutment teeth and that part of the bone which

underlies the distal end of the free-end saddle. The balance of the bony alveolar ridge will not function in carrying the load. The result will be a traumatic load to the bone underlying the distal end of the saddle and to the abutment tooth, which, in turn, will result in bone loss and loosening of the abutment tooth.

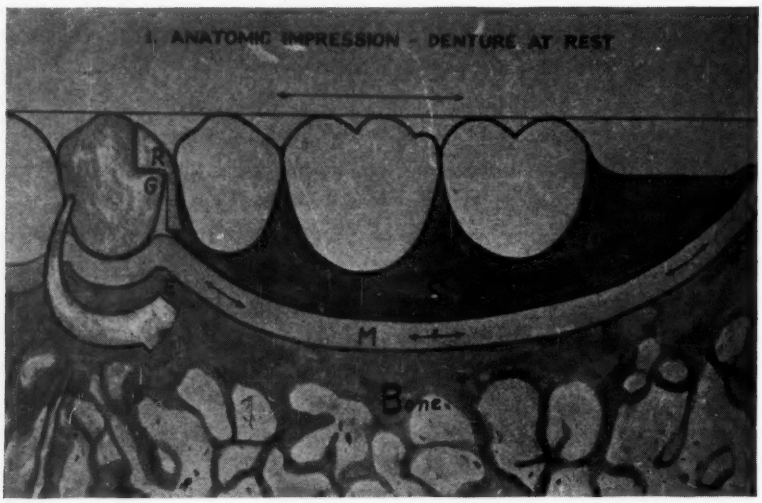


Fig. 1.—The denture base, *S*, fits the undistorted surface of the mucosa, *M*. The occlusal rest, *R*, is in contact with the floor of the rest seat *G*. There is no load on the alveolar bone, *E* - *F*.

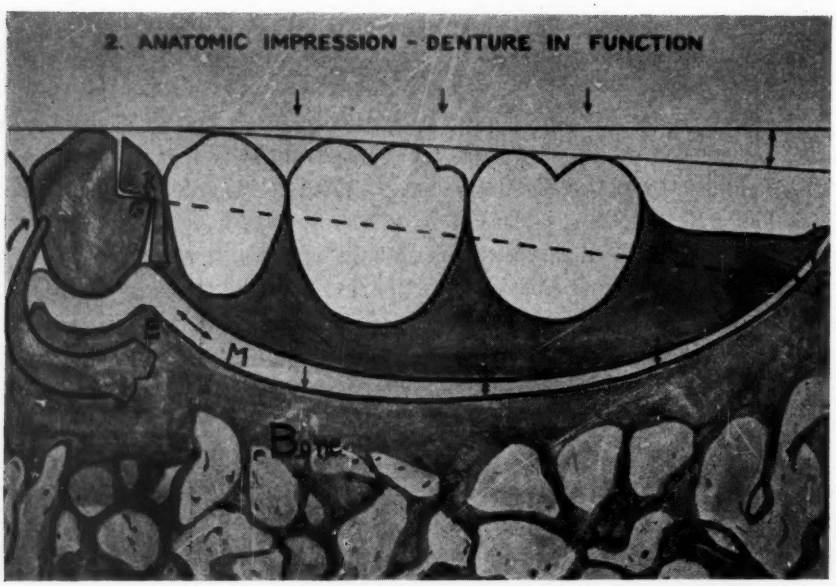


Fig. 2.—The entire masticatory load is carried by the alveolar bone near *F* and by the abutment tooth at *G*. The occlusal rest prevents the saddle from transmitting the load to the alveolar bone near *E*. The mucosa is unevenly displaced.

### REBASING METHOD

There are many who believe that every partial denture should be rebased before its final insertion in the mouth. One group believes in tissue displacement and uses impression materials of heavy consistency. They thereby introduce traumatic stresses to the underlying tissues, as previously discussed. Another group uses easy-flowing pastes which produce a rebase impression of the soft tissues at rest. During the functioning of such a partial denture, the sequence of events will be similar to that of a partial denture constructed from a one-piece impression. The occlusal rest will act as a stop, preventing an even distribution of the masticatory load by the saddle to the edentulous ridge.

### MUCOSTATIC TECHNIQUE

Addison,[5] one of the disciples of the mucostatic principle, suggests a method whereby an individual cast aluminum tray is used in combination with a zinc oxide and eugenol cement to obtain an undistorted impression of the anatomic ridge form. He then passively joins this impression with the remaining dentition by means of impression plaster. His method is based on the theory that soft tissue cannot be compressed if it is confined between a perfectly fitting denture base on one side and the underlying bone structure on the other side. The condition is said to be the same as that which exists in a closed water cylinder. Therefore, it is assumed that, if pressure is applied, there is no place for these tissues to escape, and consequently they must be rigid.

If this were true, a partial denture saddle constructed from such an impression should not move when a masticatory load is applied. This may be tested by connecting a precision attachment to such a saddle. If the male portion of the attachment is relieved at its gingival end so as to allow for movement in a gingival direction within the female part of the attachment, we have a device by which any movement of the saddle itself, when a load is applied, can be easily detected. While the quantity of this movement may vary, it was found to occur in all cases examined by the author. When a small initial load was applied to the saddle, the male attachment moved in a gingival direction, but a further increase in load did not result in any additional movement of the attachment.

While a denture base which faithfully reproduces the surface of the soft tissues at rest will be extremely stable, it is not true that the tissues under this base are absolutely rigid. We are not dealing with a closed water cylinder but with living tissues which are supplied with blood vessels which, in turn, are interconnected with the rest of the circulatory system. When masticatory load is applied to the denture base, some of the fluid content of the tissues will be forced back into the general circulation, as is evidenced by the blanching of the tissues under a clear acrylic tray. This forcing of the blood back into circulation under masticatory stress, followed by the influx of fresh blood into the tissues when pressure is relaxed, will bring about the beneficial results to the tissues of the alveolar ridge which have been long ascribed to the application of intermittent pressure. If, on the other hand, the tissue fluids were actually con-

fined under a denture base during masticatory stress, as is claimed by the proponents of the mucostatic principle, this confinement would soon result in strangulation necrosis and cell death.

While this small amount of saddle movement may not be of practical importance as far as the full denture is concerned, it will present a problem in the extension saddle partial denture where the saddle is passively related to the occlusal rest. This rest will prevent an even distribution of masticatory stresses through the saddle to the underlying tissues, as has been previously pointed out in the discussion of the one-piece impression.

### STRESS BREAKERS

The interference by the occlusal rest with an even distribution of the masticating force on the saddle areas of extension saddle partial dentures has been recognized by many who consequently have resorted to the use of some form of stress breaker. Thereby, they succeeded in eliminating torque from the abutment teeth, but at the same time they lost the very valuable vertical support that these teeth afforded the partial denture. The result was that the saddle area received all the vertical stress, and a concentrated load was placed upon a relatively small area of alveolar ridge. This, in turn, caused an inflammatory condition of the mucosa and the bone and resulted in extreme resorption of the alveolar process.

From this discussion it can be seen that while each of these methods has a specific purpose, i.e., to equalize the stresses to the supporting structures, to minimize tissue displacement, or to prevent torque to the abutment teeth, none of them was successful in solving all of these problems at the same time.

### REQUIREMENTS FOR PROPER LOAD DISTRIBUTION

The writer's opinion is that there are three definite requirements that must be fulfilled to assure proper load distribution in extension saddle partial dentures. They are:

1. The tissue surface of the saddle should be a negative reproduction of the anatomic, undistorted surface of the alveolar mucosa.
2. The masticatory load should be distributed between the ridge and the abutment teeth during function and cannot be left to be carried by the alveolar ridge alone.
3. The denture saddle should be related to the metal framework in such a way as to be similar to the relationship existing between the supporting teeth and the supporting mucosa when the latter is under a masticatory load.

In a partial denture constructed from an impression which fulfills these requirements, the occlusal rest of the partial denture should be in its position on the abutment tooth when the saddle is under a masticatory load and is seated on the fully displaced mucosa (Fig. 3). The alveolar bone will then carry the load throughout the full extent of the saddle and will be aided by the abutment teeth in carrying this load. Since the tissue surface of the saddle reflects the undistorted anatomy of the mucosa at rest, the amount of tissue displacement under masticatory load will

be kept to a minimum. Upon release of masticatory stress, the saddle will move occlusally *with* the rebounding tissues, and the occlusal rest will lift slightly off the floor of the rest seat on the abutment tooth (Fig. 4). If a masticatory load is again applied, the saddle will be able to move evenly tissueward without interference from the occlusal rest until the mucosa is fully displaced and the alveolar bone in its entirety carries a load. At this same time, the occlusal rest will contact the floor of the rest seat, and the tooth will take up some of the masticatory stresses. Inasmuch as only a small amount of load is necessary to displace the soft tissues as fully as they can be displaced by a greater load, the occlusal rest will arrive in its final

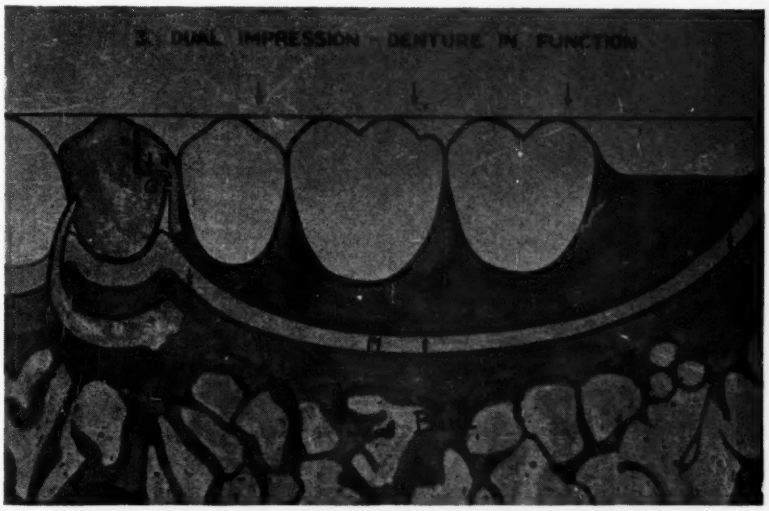


Fig. 3.—The denture base fits the evenly displaced mucosa, *M*. The masticatory load is distributed between the entire bony support *E* - *F* and the abutment tooth through the rest.

Fig. 4.—The mucosa, *M*, has rebounded. The rest, *R*, is not in contact with the floor of the rest seat, *G*. The floor of the rest seat cannot act as a fulcrum during mastication.

position in the rest seat at an early stage of the chewing stroke so that when the full masticatory load is applied to the denture, the stresses will be evenly distributed to the abutment teeth and the entire bony support. The clasp arms should be so designed and adjusted as to allow for this vertical movement of the saddle. This means that tightly gripping clasps should never be used.

Fig. 5.—The individual acrylic tray with the free gingivae exposed.

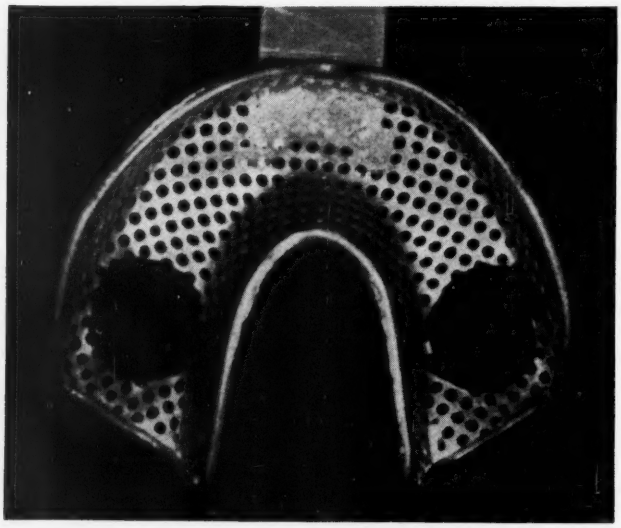

Fig. 6.—The perforated tray with holes so the fingers can exert pressure on the acrylic tray while the alginate impression material sets.

## TECHNIQUE

An acrylic tray is processed on a cast made from an impression which should include all areas of future tissue support of the partial denture (Fig. 5). The tray is selectively relieved and, when checked in the mouth, should cover the edentulous areas up to the border tissue attachments and should include the retromolar pads.

The saddles of the tray should be connected with each other by means of an acrylic lingual bar. The bar should cover the area between the muscle attachments of the floor of the mouth and the lingual gingivae of the anterior teeth. The tray should clear the free gingivae around the abutment teeth to prevent future impingement and stripping.

This tray is loaded with an easy-flowing zinc oxide-eugenol paste and brought into position in the mouth, care being taken that the soft tissues are left in their passive state. After the material has hardened, the tray is removed and the impression examined. In a successful impression, the tissue side of the tray should be fully covered with impression material, and no part of the tray itself should be visible. The material that has flowed from the tray onto the abutment teeth should now be cut away and the tray reinserted in the mouth and tested for stability.

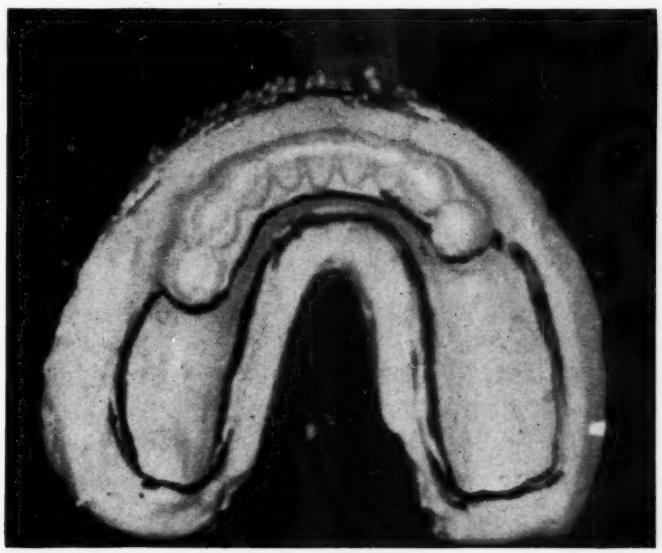

Fig. 7.—The complete dual impression. The soft tissue areas are recorded in zinc oxide and eugenol impression paste and related to the alginate impression of the teeth and free gingivae.

The next step is to make an impression of the teeth and to establish a relationship between the teeth and the mucosa in a displaced state. For this purpose, a perforated tray which has been provided with two circular openings of approximately ¾-inch diameter in the region of the first molars is used (Fig. 6). The impression of the soft tissue areas is placed in the mouth. Then, while the tray is being loaded with an alginate impression material, some of this material is used to fill in the space between the soft tissue impression and the remaining teeth. The loaded metal tray is then inserted into position over both the teeth and the acrylic tray. The index fingers are passed through the openings in the perforated tray until they contact the underlying acrylic tray; then positive pressure is exerted upon it. This pressure should be maintained until the alginate impression material has hardened. The completed impression is then removed as one unit (Fig. 7). The cast made in this impression will be a reproduction of both the surface of the teeth and the un-

distorted surface of the mucosa, but the two will be *related* to each other with the mucosa in a functional state as it would be found under the partial denture saddle during mastication. While the saddle is *related* to the occlusal rest with the mucosa in a functional state, the tissue surface of the saddle is actually a reproduction of the passive and undistorted mucosa as obtained with zinc oxide-eugenol paste in the individual impression tray.

This procedure has been in use for four years at the Columbia University Dental School with over 300 cases completed. Through a survey of regular periodic examinations of all partial denture cases, it was found that only eight cases needed refitting because of ridge resorption.

## RELINING

It should be mentioned here that to use relining as a method to refit the saddle to a resorbed ridge is inconsistent with the principles of impression making as discussed in this paper. A new dual impression should be taken, and the partial denture frame should be stripped of the old saddle and placed on the new cast. From then on, the partial denture is treated like a new case.

## SUMMARY

Various methods of partial denture construction have been discussed in relation to equalizing the tooth and soft tissue support. Three definite requirements have been stated which are necessary for obtaining optimum load distribution to the supporting structures. A method has been described which gives results that seem to fulfill these requirements.

## REFERENCES

1. McLean, David W.: The Partial Denture as a Vehicle for Function, J.A.D.A. **23**:1272-1273, 1936.
2. Cummer, W. E.: Impression in Partial Denture Service, D. Cosmos **70**:72, 278, 1928.
3. Applegate, D. C.: The Cast Saddle Partial Denture, J.A.D.A. **24**:1289, 1937.
4. Spreng, M.: Impression for Partial Dentures, 9th International Dental Congress, 1193, 1936.
5. Addison, Paul I.: Application of the Mucostatic Principle to the Precision Attachment Partial Denture, D. Survey **22**:108, 1946.

# PERIODONTAL ASPECTS OF PARTIAL DENTURE DESIGN

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INSUFFICIENT consideration has been given to the biologic factors in the design of partial dentures especially for the patient who has, or has had, periodontal disease. A casual examination of a partial denture will often show that little thought had been given to the preservation of the supporting tissues. It is illogical to supply missing teeth if in so doing any of the supporting tissues are in any way jeopardized. The purpose in constructing a partial denture is to establish and maintain the patient's health and well-being. Any appliance which does not contribute to this goal is a failure. The proper design of a partial denture presupposes a thorough knowledge of the mechanical and biologic factors involved.

A removable partial denture is an appliance which supplies missing teeth and associated structures in a partially edentulous jaw and which can be removed from the mouth and replaced at will. The main functions of a partial denture are: (1) to prepare food for deglutition and digestion; (2) to improve appearance; (3) to aid speech; (4) to distribute occlusal stress; (5) to prevent or control periodontal disease; and (6) to aid in maintaining proper jaw relation.

Before partial dentures are constructed, periodontal and periapical disease must first be eliminated and all cavities filled.

## HISTORY AND EXAMINATION

To aid in the diagnosis and treatment of the oral tissues, a history should be taken and complete clinical and roentgenologic examinations and study casts made. A history of the general condition of the patient is first obtained. It should include the chief complaint and a record of the present and past illnesses. This should be followed by pertinent information concerning the mouth. If periodontal disease has caused the previous loss of teeth, a greater ridge change can be expected than if the teeth had been lost by caries. The caries experience will also modify the treatment plan in relation to remaining and abutment teeth. The rapidity with which calculus forms may also influence treatment and results. Former partial denture wearers tolerate dentures better than the inexperienced.

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Gingival disease, particularly with regard to previous Vincent's infection, should be noted. Patients who suffer from nervous disorders, faint easily, or have epileptic seizures make partial denture wearing a problem. Where possible, fixed bridgework should be made for such patients.

A clinical examination should include a thorough observation of the teeth and soft tissues. Poor mouth hygiene and the presence of rampant caries may render it unwise to make partial dentures. Tooth brushing and gingival massage help rid the mouth of bacteria and debris, keratinize the gingiva, and increase the blood supply—all beneficial to the health of the periodontium and to the wearing of a partial denture. An examination of the tongue may reveal signs of systemic disorders which may influence the wearing of a partial denture, e.g., vitamin deficiencies or pernicious anemia. The muscle tone, coating, and papillae of the tongue should be observed. Scarring of the tongue may indicate epilepsy. The color, density, contour, and relationship of the mucosa and attached gingivae deserve careful consideration. Ulcerations, tumors, enlargements, fistulas, and other pathologic conditions should be treated before the prosthetic appliance is considered. A close examination of the mouth will reveal much about mouth care and habits. Certain habits, such as biting or sucking foreign objects or mouth tissues, gritting or grinding of teeth, and occupational habits associated with the mouth, not only increase the difficulty of partial denture design, but also the wearing of the denture.

The presence and location of periodontal pockets should be determined and their depth measured by a calibrated periodontal probe and recorded on a chart in millimeters. No examination of roentgenograms can take the place of this procedure.

The causes of vertical and horizontal impaction of food should be recognized. This will require inspection of the interproximal tissues and the contiguity of the teeth as well as cuspal and occlusal relations.

Consideration must be given to the type of edentulous ridge, whether large or small, smooth or irregular, and the thickness of the soft tissue. The gingival tissues should be palpated to express material for inspection. The mobility of teeth should be determined, remembering that teeth may often be rotated or depressed as well as moved laterally. Lateral movement can best be detected by moving a tooth with an instrument rather than the fingers. The degree of movement is recorded as 0, 1, 2, or 3. Normal mobility is recorded as 0, the first distinguishable movement greater than normal is 1, the movement of a tooth 1 mm. in any one direction from its normal position as 2, and similar movements more than 1 mm. are recorded as 3.

The roentgenologic examination should include at least fourteen periapical films and two posterior bite-wing films. The interpretation of these films will aid in detecting pathoses in the hard tissues, such as periodontal and periapical conditions, the conformation of the bone, the presence of interproximal cavities and calculus, residual roots, and radiolucent areas and unerupted teeth. The shape and size of the roots of the teeth can also be determined.

Accurate, anatomically articulated study casts will also aid in the diagnosis, prognosis, and plan of treatment. These casts permit the study of the shape,

position, and relationships of teeth and jaws from every angle. The following conditions should be observed: tori, soft and hard tissue enlargements, overbite, overjet, edge-to-edge, crossbite, torsiversion, migration, extrusion, evidence of premature contact, and other occlusal relations. This information will be of value in demonstrations to the patient, in determining which teeth should be extracted, and in the equilibration of the teeth before construction is begun.

A cast surveyor should be used in conjunction with the study casts to design the clasps so that there will be no interference when the appliance is inserted or removed. If teeth are forced together or apart in the course of these operations by nonparallelism or by placing the clasps in undercuts adjacent to edentulous areas, rapid destruction of the periodontal membrane and bone resorption will occur. The following will aid materially in reducing interference: (1) relief of enamel contours or restorations adjacent to spaces; (2) surgical reduction of eminences in edentulous areas; (3) repositioning teeth by orthodontic measures; and (4) extraction of malpositioned teeth which fulfill no useful function.

## ETIOLOGIC FACTORS

After evaluation of the history, clinical examination, interpretation of the roentgenograms, and examination of study casts, the probable etiologic factors should be determined. These are usually local but may be systemic or a combination of both. The local causes may be irritative or dysfunctional. The most common irritative cause is calculus. Improper brushing and massage, inadequate dentistry, food impaction, bacterial infection, mouth breathing, nondetergent diet, or metallic gingivitides are other causes. Dysfunctional causes are overfunction, underfunction, abnormal habits, mouth breathing, nondetergent diet, and food impaction. The following systemic conditions may affect the periodontal tissues or the oral mucosa: diabetes, nutritional disturbances, endocrine disturbances, allergies pregnancy, nervous disorders, and syphilis. With this information at hand, the dentist is properly prepared to treat a patient with periodontal disease and to design and make a partial denture.

In designing the partial denture, the preparation of the natural teeth must be considered. All necessary restorations in natural teeth should be inserted before the partial denture is constructed.

Abutment teeth, carious or sound, may require restorations. These teeth are best restored in most instances by gold inlays which will permit the reception of rests, clasps, or retainers and properly restore contiguity and contour for the deflection of food. In restoring natural teeth, the size of the occlusal surfaces should not be increased to a degree that would require chewing forces greater than the supporting tissues can tolerate. Occlusal carving in general should conform with the attritional changes. In many instances an abutment tooth will fare better if it is fixed to an adjacent tooth by means of inlays soldered at the contact area. Such splinting will materially lengthen the life of the teeth and restorations, provided the interproximal spaces are properly shaped for interdental stimulation and cleaning. The equilibration of the natural teeth is now planned and executed, bearing in mind that the occlusal planes in the oppos-

ing arches should be as nearly normal as possible. Extrusion and migration of teeth may pose difficult problems. The reshaping of natural tooth structure to receive clasps, rests, and retainers is also carried out at this time. Reshaping of the surfaces of well-worn occlusal areas of posterior teeth so as to make the occlusal table narrower buccolingually is all too seldom undertaken. Sometimes it is possible and desirable to restore marginal ridges and grooves as well as cusps and sulci by grinding these teeth.

## PARTIAL DENTURE DESIGN

The various parts of a partial denture will now be considered from the standpoint of their possible relationship to periodontal disease.

*Rests.*—The main functions of a rest are to:

1. Transmit occlusal stresses along the long axis of the tooth.
2. Distribute stresses over the greatest number of teeth.
3. Maintain clasps in predetermined position.
4. Act as an indirect retainer and redivide lever action.
5. Prevent the formation of periodontal pockets by proper deflection of food.

1. *Transmit occlusal stresses along the long axis of the tooth:* The fibers of the periodontal membrane are better able to resist pressure exerted along the long axis of the tooth. The brunt of resistance is offered by the oblique fibers in the incisal part of the periodontium, which act as a suspensory mechanism, and by the cushioning effect of the hydraulic mechanism. When lateral stress is exerted, the oblique fibers are subjected to a compressive force on one side while the fibers on the opposite side will be stretched to such an extent that they may be torn. A force which is tolerated readily if exerted along the long axis of the tooth may be highly destructive if applied in a lateral direction.

The alveolar bone and periodontal membrane depend on normal functional stimuli to preserve their structure. They change when over- or understimulated. The oblique fibers of the periodontal membrane become loosely arranged and the membrane thin when the tooth is not used. If such a tooth be used as an abutment or if it acquires an antagonist, the change causes soreness until the membrane thickens and the fibers are properly arranged. Alveolar bone atrophies during disuse. Overstimulation may cause dissolution or sclerosis followed by eventual breakdown. Old age, malnutrition, or postmenopausal changes may weaken bone resistance to external forces.

2. *Distribute stresses over the greatest number of teeth:* The use of multiple rests will not only diminish the stresses brought to bear on the ridge in the edentulous areas, but will also permit a more equitable distribution of the load on the abutment teeth. For example, it would be better to use rests on four abutment teeth, if available, rather than on a smaller number. By so doing, any given stress which might prove destructive if carried by only one or two abutments may become a tolerable load if it is possible to distribute the same stress over a greater number of teeth.

3. *Maintain clasp in predetermined position:* Any slight resorption of the ridge will cause a change in the predetermined position of the clasp unless

a rest is used. This change in clasp position would bring about (1) loss of retention; (2) failure of the clasp to function with maximum efficiency in the distribution of lateral stress; and (3) impingement of the clasp on soft tissue, resulting in inflammation or destruction of these tissues.

4. *Act as an indirect retainer and redivide lever action:* When a rest is used as an indirect retainer, it is possible to redivide lever action on a vertical plane and thus minimize the magnitude of the force which might otherwise come to bear on an abutment tooth. Vertical, rotational movement of a clasp on an abutment tooth may also be diminished by the use of a rest as an indirect retainer.

The so-called continuous clasp, which is in reality not a clasp but a rest, will also aid in distributing lateral stress and in redividing the lever action. The application of a continuous clasp to stabilize the teeth contacted is based on an erroneous conception of the use of this part of the appliance. It should be obvious that teeth which are in need of support will not receive that support by permitting an additional load to be placed upon them. A continuous clasp does not act as a splint.

5. *Prevent the formation of pockets by the proper deflection of food:* A rest properly placed on contiguous teeth which have lost some support may deflect food from the occlusal embrasure. Food impaction readily occurs in instances where there is anteroposterior movement of teeth. Failure to prevent food impaction may cause enlargement or destruction of the interdental papillae, interproximal cavities, or bone loss. Properly placed rests will deflect the food while the clasps will prevent further separation of the teeth. Rests may also be used to protect the papillae in instances where the teeth have erupted in such a manner that there are large spaces between them.

*Clasps.*—A clasp is used to perform two main functions:

1. Act as a primary retainer.
2. Aid in the distribution of lateral stresses.

1. *Act as a primary retainer:* This is one of the most important functions of the clasp in that it aids in preventing vertical movement of the appliance. To act as an efficient primary retainer, the clasp fingers should be placed apical to the greatest diameter of the tooth either buccolingually or mesiodistally. The clasp should be so designed that the fingers will remain passive after they are in place so as to avoid continuous pressure on the tooth. Unless this is done, the clasp will produce a degenerative change.

2. *Aid in the distribution of lateral stresses:* The clasp arms should be made rigid so that when lateral stresses come to bear on the appliance these stresses will be opposed not only by the mucosa but also by the abutment tooth. A clasp may be designed so as to act as an efficient primary retainer; this would not necessarily aid in the distribution of lateral stress unless the clasp arms were made rigid.

In general there are two types of clasps: (1) circumferential and (2) bar type (Roach). Both types of clasps may be used to advantage. From the standpoint of distribution of lateral stresses, however, the circumferential clasp

is more effective than the bar type, and there is less tendency toward food collection. On the other hand, the circumferential clasp may have a tendency to deflect food in mastication from the margin of the free gingival tissue so that these tissues receive no stimulation, and food may accumulate between the clasp and the gingiva.

*Palatal Bars.*—Some of the functions of a palatal bar are to:

1. Distribute stresses from one saddle to the other or in unilateral cases from one saddle to the teeth on the opposite side of the arch. To accomplish this result the palatal bar must be made rigid.
2. Help distribute part of the load of occlusal stress to the soft tissue of the vault if made to cover sufficient area. Where the remaining maxillary teeth would be unable to carry a substantial share of the load, a wide palatal bar may be used in order to place more of the stress on the mucosa.
3. Join the saddles.
4. Carry part of the prosthesis.
5. Maintain the relationship of the clasps to each other.

A common cause of gingival irritation is the placing of the palatal bar either too close to or over the margin of the gingiva. Pressure on this tissue, or closely adjacent to it, results in enlargement or recession of the tissue and in periodontal disease. Failures have often resulted where an attempt was made to avoid impingement of the tissue by carrying the palatal bar over the cingulum of the teeth despite the presence of relief areas corresponding to the location of the free gingival tissue.

*Lingual Bar.*—The main function of a lingual bar is to distribute lateral stresses between the abutment teeth and saddles. To accomplish this the lingual bar must be made rigid. Care must be taken in the proper placement of the lingual bar. For example, in free saddle cases, if the lingual bar is placed too close to the ridge, slight upward movement of the distal part of the saddle might cause the bar to impinge upon the tissue and cause ulceration. Again, if the bar is placed too low, the bar will impinge upon the lingual frenum when the patient makes functional tongue movements. In addition, the lingual bar serves to join the saddles, maintain the relationship of the clasps, and may carry part of the prosthesis.

*Saddles.*—The function of the saddle is to carry the teeth to be supplied, supply missing tissues, and aid in the distribution of occlusal stresses. Obviously, the greater the area covered by the saddle, the less will be the occlusal stress per unit area. Frequently, considerable ridge destruction has resulted from the insufficient distribution of stresses over the mucosa by too small a saddle. The saddle should end about 3 mm. away from the free gingival tissue when adjacent to an abutment tooth. The saddles also aid in the stimulation of the tissues covered by the saddle. They may also act as secondary retainers.

*Artificial Teeth.*—In order to diminish occlusal stresses, which would otherwise be distributed to the mucosa and abutment teeth, the artificial teeth should be made narrower buccolingually than the natural teeth. To reduce occlusal

stresses further, particularly lateral stresses, teeth with a reduced cuspal angulation should be used. Futhermore, to reduce lever action (tilting) on the prosthesis, the teeth should be placed as far to the lingual as is consistent with the position of the remaining natural teeth and the size of the tongue.

## SERVICING

Breakdown of the tissues surrounding the abutment teeth and in the edentulous areas may become rapid unless the patient returns for proper servicing of the denture. Any appreciable amount of ridge resorption will throw additional load on the abutment teeth and result in their early loss.

To insure healthier tissues, the patient should be instructed as to insertion, removal, length of time dentures should be worn, and in the cleaning of the partial denture. The method of massage and stimulation of the gingival tissues and the cleaning of the natural teeth should be mastered by the patient. In addition, the denture should be cleaned and inspected periodically by the dentist.

## SUMMARY

Tooth loss is lost function, and partial dentures should as far as possible compensate for tooth loss in terms of functional performance and in preserving the health of oral tissues. Partial dentures are no more permanent than their abutments, the mucoperiosteum and bone under their saddles.

## REFERENCES

1. Applegate, O. C.: Stresses Induced by a Partial Denture Upon Its Supporting Structures and Practical Methods of Control, Proc. D. Centenary, pp. 308-319, 1940.
2. Glickman, I.: Periodontal Response to Partial Dentures, J. Am. Dent. A. **37**:311-316, 1948.
3. McLean, D. W.: Fundamental Principles of Partial Denture Construction, J. Tennessee D. A. **19**:108-118, 1939.
4. Orban, B.: Tissue Reactions Encountered in Partial Denture Prosthesis, Illinois D. J. **10**:42-46, 1941.
5. Trapozzano, V. R.: Partial Dentures, in Grossman, L. I.: Handbook of Dental Practice, Chapter 16, Philadelphia, 1948, J. B. Lippincott Company.

# MOUNTING MASTER AND REFRACTORY CASTS IN THE ARTICULATOR IN PARTIAL DENTURE CONSTRUCTION

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MASTER casts, and in some cases the refractory casts as well, are mounted in the articulator in order that proper occlusions may be established on the partial denture prosthesis, and it is important that this be done at the proper stage in the over-all construction procedures.

My experience has indicated the advisability of mounting the master casts in the articulator *before making the metal framework,* either cast or assembled, in those cases (1) where porcelain facings or tube teeth are to be used, (2) where extensive occlusal rests are to be opposed by the cusps of natural teeth, (3) where considerable occlusal surface area is to be supplied by a portion of the metal framework, or (4) where the vertical dimension is to be increased on the remaining natural teeth by means of the metal framework, as would be the case when a cast occlusal splint or occlusal overlays are made.

The master casts may be mounted in the articulator *after the metal framework is made,* either cast or assembled, in those cases (1) where the opposite jaw is being supplied with a complete artificial denture which is being made at the same time or later or (2) where the establishment of a desirable occlusion on the metal framework, by grinding in the mouth, would be a simple procedure.

For cases presenting extensive edentulous areas, such as free-end extension designs, the making of jaw relation records is greatly simplified, and the records are more likely to be accurate when the metal framework is completed previous to the making of jaw relation records and the mounting of the master casts in the articulator.

## SURFACE TREATMENT OF ARTIFICIAL STONE CASTS AND OF WAX JAW RELATION RECORDS

Artificial stone casts are less likely to become mutilated when occluded and rubbed together and may be more accurately seated into wax jaw relation records when their surfaces have been treated with a very fine grade of talcum powder.

The powder should be burnished onto the working surface of the cast with the fingers at intervals during construction procedures. This produces a smooth,

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greasylike surface which is more like that of the natural teeth and which minimizes the wearing away of the occlusal surfaces when the casts are occluded.

This treatment is especially indicated previous to the seating of finished metal frameworks on master casts. The framework glides to place more easily because the frictional resistance offered by the crystalline surface of the artificial stone teeth is minimized.

The occlusal surfaces of wax jaw relation records should also be treated with talcum powder, applied with a camel's hair brush, and the excess should be blown away previous to occluding them with an artificial stone cast.

## ARTICULATORS

Adjustable type articulators should always be used when constructing dental prosthetic appliances. While it is not to be expected that solid axis-type articulators can be adjusted to copy the exact eccentric occlusions of natural teeth, it is possible to produce occlusions on such articulators that meet all of the necessary requirements, within practical limits.

It is a fact, of course, that an articulator offers no more than a means to an end, and the results obtained from its use will be no better than the operator's ability to make jaw relation records on the patient and to utilize them correctly in the instrument.

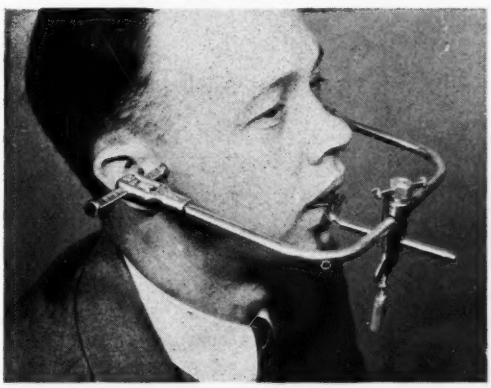

Fig. 1.—The completed face-bow record on the patient. The inner ends of the condyle rods contact a point on the face one-half inch anterior to the tragus of the ear on a line toward the external canthus of the eye. A properly made face-bow record need consume no more than two minutes of the operator's time.

## THE FACE-BOW RECORD

When solid axis-type articulators, such as the Hanau model H, or arbitrary type articulators, such as the Gysi Simplex, are used, the maxillary cast should always be positioned in the instrument by means of a properly made face-bow record. This is especially true in the case of arbitrary-type articulators.

In the anatomy, the maxilla is related very definitely to the glenoid fossae in each individual case, and the nature of eccentric jaw movements is influenced

to a great extent by this relationship. It is therefore important that the maxillary cast be correctly related to the substitute mechanical joints of the articulator. The purpose of the face-bow record is to establish this relationship. When the face-bow is properly used, the procedure need not consume more than two minutes of the operator's time (Fig. 1).

*Technique.*—If the maxilla is being supplied with a complete artificial denture, the face-bow fork is inserted in the maxillary occlusion rim in the conventional manner. If both anterior and posterior natural teeth are present in both jaws, a roll of wax is formed on the face-bow fork, and the patient is directed to occlude into, but not through, the wax. All wax on the maxillary side is cut away except the cusp tip indentations of the maxillary occlusal surfaces or of the occlusion rims, and the maxillary cast is seated in it, for mounting in the articulator with plaster of Paris (Fig. 2).

If all natural posterior teeth are missing in one or both jaws, a baseplate with an occlusion rim is constructed to provide the missing occlusal surfaces, and the same procedure is followed as when all natural posterior teeth are present.

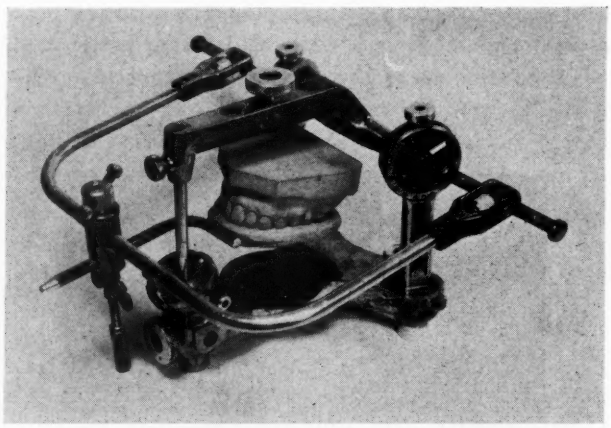

Fig. 2.—The completed face-bow record is positioned on the articulator where it serves to support the maxillary cast in its correct relation to the mechanical joints of the articulator while it is being attached to the instrument with plaster of Paris.

## RELATING THE MANDIBULAR CAST TO THE MAXILLARY CAST IN THE ARTICULATOR

In complete artificial denture construction, the mandibular cast is related to the maxillary cast, in the articulator, by means of a centric jaw relation record made on the patient. The artificial teeth are then arranged into centric occlusion, and thus harmony of centric jaw relation and centric occlusion is established. This is essential to desirable results.

Harmony of occlusions and jaw relations in natural dentures is also desirable but does not always exist. Centric occlusion of natural dentures is very often associated with some degree of eccentric jaw relation. Such a condition should be detected in the examination and should be corrected before the final impression is made. In the majority of cases, occlusal disharmonies of the natural

teeth may be corrected by judicious spot grinding or with individual tooth restorations, but in some cases it may be deemed advisable to proceed with the construction of a partial denture even though perfect harmony of centric jaw relation and centric occlusion of the remaining natural teeth may not exist.

Regardless of which condition may prevail in a given case, the occlusion presented by the partial denture should be in exact harmony with that of the remaining occluding natural teeth. To meet this requirement, we must give special consideration to the manner in which the master casts are related to each other in the articulator.

I have observed many hundreds of cases in which opposing casts have been sent to dental laboratories for the construction of partial dentures. The most outstanding defect in these cases has been the almost total disregard for proper mouth preparation previous to the making of the final impressions, but next to this has been the very careless manner in which the casts have been related to each other.

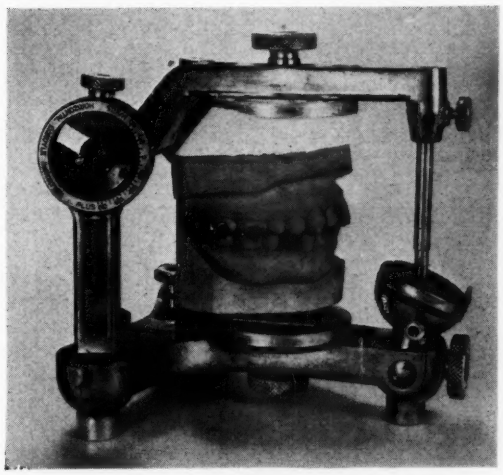

Fig. 3.—The molars are absent on the left side of this case, but sufficient natural teeth remain to assure a stable centric occlusion. Therefore, the lower cast is related to the upper cast as illustrated without any recording material being interposed.

The most common cast relationship record furnished to laboratories consists of a gob of wax into which the patient has apparently closed in some one of his millions of possible jaw relations.

In cases where *sufficient natural teeth remain, in the opposing dental arches, to provide a stable centric occlusion of the casts,* it is common practice for dental laboratories to discard the so-called wax check bite and to relate the casts in the articulator in their true centric occlusion. This is as it should be.

No type of recording material should ever be used in such partial denture cases, assuming, of course, that the casts are accurate replicas of the patient's mouth. (This statement must not be confused with the relating of casts of natural dentures in the articulator for occlusion studies. Delicate interocclusal jaw relation records are essential for this purpose.)

All partial denture cases fall into one of two groups so far as relating the casts to each other is concerned. In one group, the casts should be related to each other in the articulator by their centric occlusion, without an interposed recording medium. This includes those cases where sufficient natural teeth remain in each arch to bring about a stable centric occlusion relationship of the casts (Fig. 3). This method permits the construction of a partial denture that presents occlusions which are in harmony with those of the remaining natural teeth.

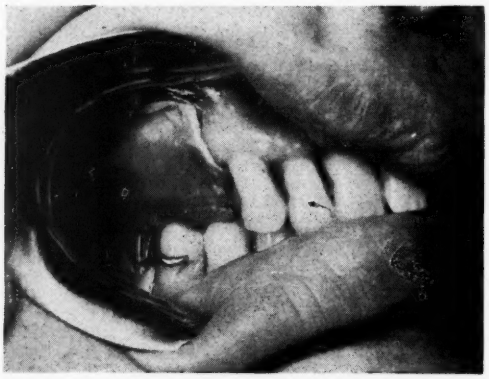

Fig. 4.—In the absence of sufficient natural teeth to assure a stable centric occlusion of the casts, an interocclusal centric jaw relation record is made between occlusion rims in the patient's mouth.

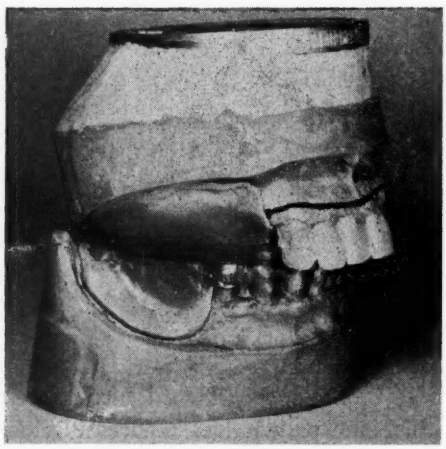

Fig. 5.—The completed interocclusal centric jaw relation record is used to relate the mandibular cast to the maxillary cast for attachment to the articulator.

In the other group the mandibular cast is related to the maxillary cast in the articulator by means of a centric jaw relation record made on the patient (Fig. 4). This includes those cases where all posterior teeth, in one or both jaws, are to be supplied with either a complete or a partial denture or where the vertical dimension is to be increased by the use of the partial denture framework in the form of overlays on the natural teeth. In these cases an interocclusal centric jaw relation record is made between the occlusion rims and opposing natural posterior teeth, if present, at the desired vertical dimension. The mate-

rial used for making this record should initially be very soft to avoid displacing the mucosa under the baseplates. The opposing casts are positioned in the finished centric jaw relation record for attaching the mandibular cast to the articulator (Fig. 5).

### ADJUSTING THE CONDYLE ELEMENTS OF THE ARTICULATOR

If the remaining natural teeth consist of anteriors and molars on each side of the arch, and if these teeth present stable centric and protrusive occlusions in the mouth, the condyle elements of the articulator may be adjusted by means of the protrusive occlusion of the casts.

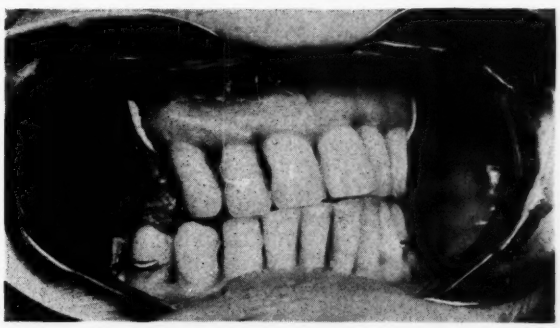

**Fig. 6.—The completed interocclusal protrusive jaw relation record constitutes an actual occlusion in the patient's mouth. This record enables the operator to adjust the articulator later so that this particular static occlusion may be reproduced in the artificial tooth arrangement.**

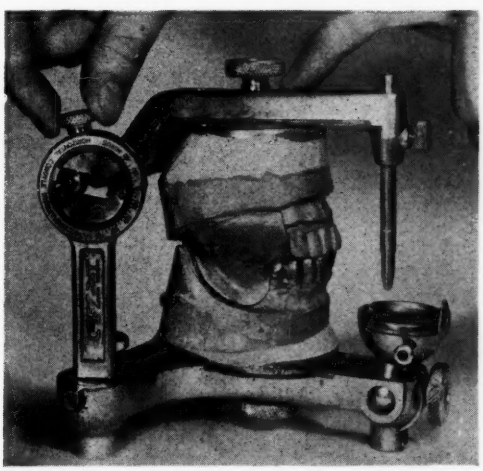

**Fig. 7.—The condyle elements of the articulator are adjusted so that the same protrusive occlusion exists in the articulator as existed on the finished interocclusal record in the mouth.**

If sufficient natural teeth to serve this purpose are not present, baseplates and occlusion rims are constructed to supply the missing occlusal surfaces. A roll of wax is then positioned over one of the occlusal arches, and a protrusive jaw relation record is made in the mouth in the conventional manner (Fig. 6). This record is used for adjusting the condyle elements of the articulator (Fig. 7).

## ANTERIOR GUIDE ADJUSTMENT

The term anterior guide seems more appropriate than incisal guide because this device serves as the third leg guide of the entire mechanical dental tripod. It is therefore related to both the anterior and posterior segments of the opposing occlusal arches, and not alone to the incisal guidance which results from the positional relationships of the upper and lower anterior teeth.

The inclines of the anterior guide, when properly adjusted, constitute a projected mean of the guidances furnished by the condyle indications and the steepest guidance furnished by the occluding dental arches in any given cast relation in the articulator.

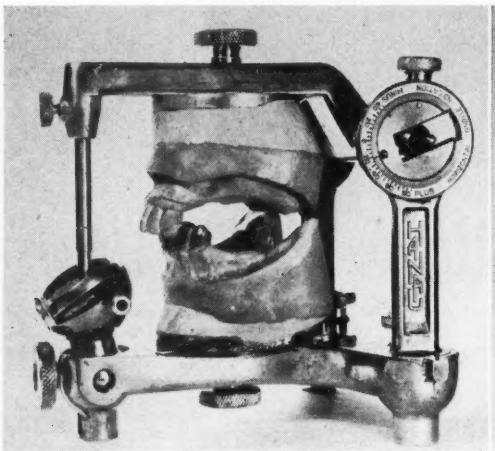

Fig. 8.

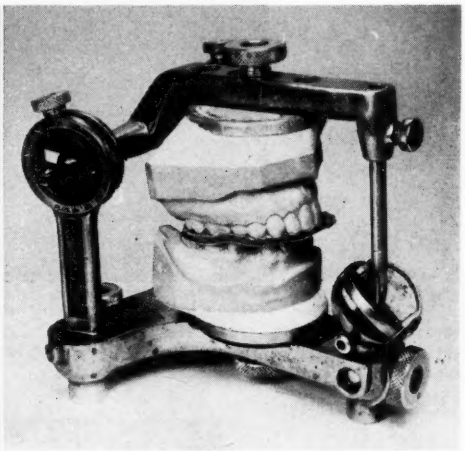

Fig. 9.

Fig. 8.—The anterior guide of the articulator is adjusted by placing the opposing casts into their various eccentric relations to each other and manipulating the guide planes so that they maintain contact with the lower end of the anterior pin of the instrument.

Fig. 9.—The casts are separated about 3 mm. at the biscuspid region, and the anterior pin is locked to maintain this opening. A foil-coated wax record is then made between the casts, with the anterior pin contacting the floor of the anterior guide when the record is completed.

In other words, it is a mechanical device which, in combination with the anterior pin of the articulator, serves to maintain the established vertical dimension and which may be adjusted to serve, in combination with the condylar guides, to direct the upper and lower casts in their various relations to each other.

In those cases presenting opposing natural teeth in both jaws, the anterior guide is adjusted by placing the casts in their various eccentric relations to each other with the cast teeth in occlusion and by manipulating the adjustable planes of the anterior guide to maintain contact with the lower end of the anterior pin.

In partial denture cases it is advisable to adjust the anterior guide so that the teeth on the casts will not quite touch each other in eccentric relations to prevent their being worn down or fractured.

In those cases where all of the posterior teeth in both jaws are being supplied on partial dentures, the anterior guide is adjusted by placing the casts into their eccentric relations to each other, according to the incisal guidance presented by the anterior teeth, at the accepted vertical dimension and by manipulating the planes of the anterior guide so that they maintain contact with the lower end of the anterior pin (Fig. 8).

When one jaw is being supplied with a full denture and the opposite jaw presents several natural posterior teeth, it is advisable to arrange one or more of the posterior teeth on the edentulous cast into the best possible state of balanced articulation with their opponents and then to adjust the anterior

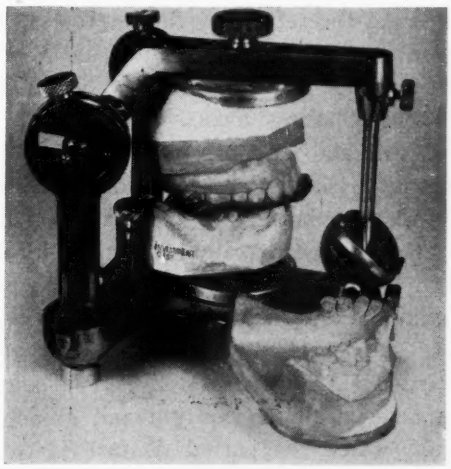

Fig. 10.—The lower master cast with mounting ring attached is removed from the articulator, and the refractory (investment) cast is positioned in the foil-coated wax record.

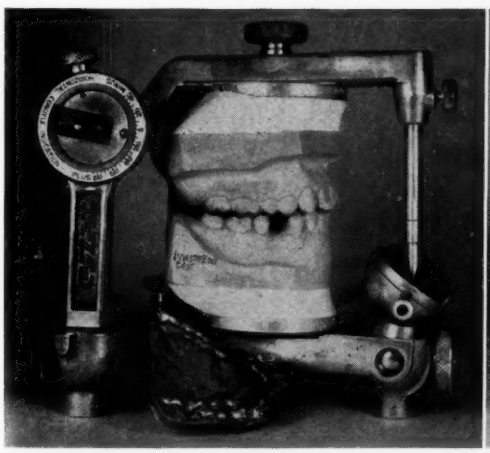

Fig. 11.

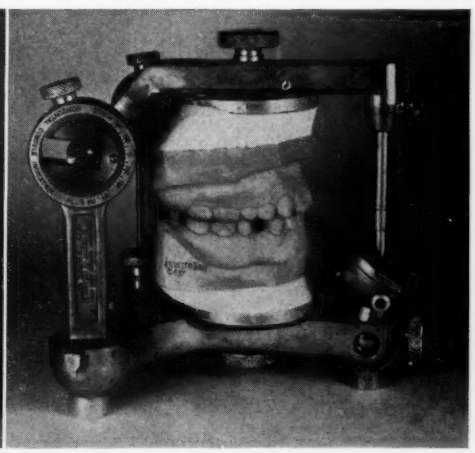

Fig. 12.

Fig. 11.—After the refractory cast is attached to the articulator with plaster of Paris, the foil-coated record is removed.

Fig. 12.—The anterior pin is returned to its original adjustment. The casts should occlude exactly as do the master casts, thereby enabling the formation of correct occlusal surface morphology on the wax casting pattern or on artificial teeth.

guide in the same manner as when opposing natural posterior teeth are present. It should be remembered that vertical dimension exerts a marked influence upon the incisal guidance furnished by opposing natural anterior teeth.

The reader is referred to an article entitled "Selective Incisal Guidance in Full Denture Construction" by the author for a more detailed discussion of this subject as it applies to full denture construction.

## MOUNTING REFRACTORY CASTS IN THE ARTICULATOR

At the beginning of this paper, I suggested that in certain cases the master casts should be mounted in the articulator before making the metal framework. It is in these same cases that the refractory cast or casts should also be mounted in the articulator in order that proper occlusal surface morphology may be established on the wax casting pattern or on artificial teeth.

*Technique.*—With the opposing master casts in the articulator, separate their occlusal surfaces 3 mm. and lock the anterior pin to maintain this opening. Apply talcum powder to the occlusal surfaces of the cast teeth. Soften and stack three layers of baseplate wax, and place tin or aluminum foil on the two outer surfaces. Open the articulator and occlude the casts against the tin-foiled soft wax until the lower end of the anterior pin almost touches the floor of the anterior guide, being sure that the casts are maintained in centric relation. In the Hanau model H this would mean keeping the balls in the condyle elements forward against their stops. As the wax cools, complete the closure to bring about contact of anterior pin and guide (Fig. 9).

Remove the cast on which the partial denture is to be constructed, with its mounting ring, and position a new ring. The duplicate cast, in refractory material, is positioned in the foil-coated wax record and attached to the articulator (Fig. 10). Repeat this procedure with the opposing cast if it also has been duplicated in refractory material. Remove the interposed cast relation record, release the anterior pin lock nut, and carefully occlude the casts (Figs. 11 and 12).

The fact that a thick cast relation record is used is of no concern in this procedure because the opening and closing are done on the same identical axis.

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# CLEFT PALATE PROSTHESIS REHABILITATION

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OF THE wide variety of cases which come within the province of oral dental prosthetics, the congenital cleft palate is one of the most common. Literature on this subject has grown to the point where it may be regarded as quite sizable, but cleft palate literature in itself is of little value unless it is related to extensive experience with various types of cases. The point to be emphasized, I believe, is the end result of the treatment, because facial and oral deformities accompanying this condition may have grave psychologic effects on the patient. Defective speech is one of the main motivating factors which impel the patient with a cleft palate to seek the services of a prosthodontist.

From the esthetic and psychologic viewpoints, prosthetic appliances are of enormous value, for without them a person with a cleft palate finds it virtually impossible to achieve a normal, happy existence.

Part One, the background, is a birds-eye view of the subject's many ramifications. Part Two is a description of the method I use in the construction of a prosthetic obturator, with a vomer, pin lock hinge, and wing-type velum, for a Class V (unilateral) cleft palate.

## PART I

### EMBRYOLOGY, ANATOMY, AND PHYSIOLOGY OF THE OROPHARYNGEAL STRUCTURES

When studying normal tissues and their functions, it is virtually impossible to separate the sciences of embryology, anatomy, and physiology, of which the dentist, as well as the surgeon, must have a thorough knowledge before attempting to restore the abnormal to the normal.

*A. Embryology.*—A study of embryology shows us the development and formation of the oral and nasal cavities. Such knowledge of the early development of the palate is necessary to the understanding of the different varieties of cleft palate.

In early embryonic life, the future oral and nasal fossae form one continuous chamber, the stomodeum, which is a depression or invagination between the head and the pericardium. This primitive mouth is separated from the foregut by the buccopharyngeal membrane which ruptures during the fifth week. Later, lateral boundaries appear to form the upper part of the mouth and the floor of the nasal

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cavities. The stomodeum gives rise to the floor of the mouth and the tongue. The appearance of the shallow stomodeum soon changes. It is bounded by several prominences placed above, below, and at the sides, from which the several parts of the face are eventually formed.

Between the fifth and eighth weeks, there appear the olfactory pits, the rudimentary nose, the nasal septum, and the lips. Coincident with the lip development, the primitive mouth becomes divided into an upper (nasal) cavity and a

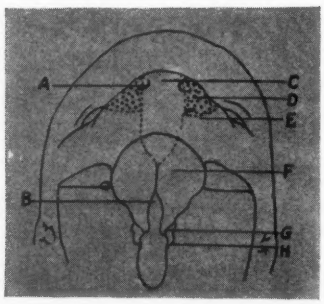


Fig. 1.—A diagrammatic sketch. *A* indicates the interior naris; *B*, cleft in the palate; *C*, middle nasal process; *D*, lateral nasal process; *E*, maxillary process; *F*, processus palatinus; *G*, uvula; *H*, palatopharyngeal fold. (From Dorrence, George M.: Arch Surg. **21**:194, 1904).

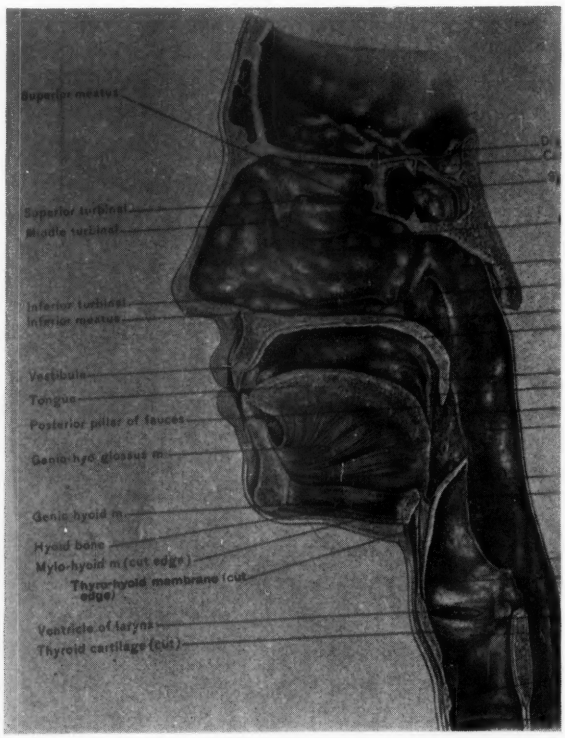


Fig. 2.—Vertical sections of the mouth, hard and soft palates, nose, and pharynx. (From Deaver, John B.: Surgical Anatomy, Vol. 2, Philadelphia, The Blakiston Company, p. 212.)

lower (oral) cavity. This is accomplished anteriorly by the median nasal process, which forms the medial boundaries of the nasal pits and fuses inferolaterally with the maxillary processes, thus forming the groundwork for the upper jaw and lip, the bridge and septum of the nose, the incisive portion of the maxilla, and the anterior or premaxillary part of the hard palate. Union of this portion of the palate commences anteriorly at the eighth week and continues backward, forming the soft palate. The uvula is the last portion to unite, being completed usually about the tenth week.

According to Orban,[1] the deformity known as cleft palate results from a lack of fusion of the palatine processes with each other and with the nasal septum. In unilateral defects one process fuses with the lower border of the septum so that one nasal cavity is completely separated from the oral cavity. The fusion of the palatine processes commences at their anterior ends and proceeds backward. The process of fusion may be interrupted at any time. This explains the different types of cleft palate. The cleft may be limited to the uvula, may exclude a portion of the soft palate or hard palate, or may involve parts of or the entire hard and soft palates.

*B. Anatomy and Physiology.*—Regarding anatomy and physiology of the lips, nose, tongue, hard and soft palates, and pharynx:

(1) The lips are composed of the skin, the superficial fascia, the orbicularis oris muscle, areolar tissue, and mucous membrane. Voluntary movements of the lips produce a constriction or interruption of the expired air, resulting in the important speech sounds.

(2) The walls of the nose are formed above by the nasal bones, the nasal spine of the frontal bone, and the nasal processes of the superior maxillary bones; below, they are formed by the lateral cartilages of the nasal fossae. In addition to their function of serving as passages for air, the nasal fossae and the sinuses give resonance to the voice, remove particles of dust, warm and moisten the inhaled air, and contain organs of the special sense of smell. The normal functions of the nose and the nasal fossae are disturbed when there is a complete cleft of the lip and of the palate. The vomer, the ploughshare bone, forms the posterior part of the nasal septum. It is a thin pentagonal plate of bone, normally situated in the mid-sagittal plane between the two processes, the wings, or alae, of the vomer (Figs. 3 and 4).

(3) The tongue is a firmly movable muscular organ which occupies nearly the entire floor of the mouth, with which its mucous membrane is continuous. The muscles of the tongue are divided into an extrinsic and an intrinsic group. Owing to the muscular arrangement, the tongue is extremely mobile and can make the many articulatory contacts with the teeth, gums, and the hard and soft palates. The tongue can also modify the stream of air from the lungs in the production of speech sounds as well as shape the mouth to produce resonance in connection with vowel sounds. The mobility of the tongue should be carefully observed in cleft palate patients.

(4) The hard palate is formed by the horizontal processes of the maxillary and palate bones. It is bounded anteriorly and laterally by the alveolar processes

which bear the teeth ends posteriorly in the maxillary tuberosities on each side. The posterior margin, which is free, gives attachment to the palatal aponeurosis. The hard palate separates the mouth from the nasal cavity, preventing the passage of food, air, and saliva into the nasal cavity and the passage of nasal secretions

Fig. 3.—Normal sagittal section of the hard and soft palates and uvula. (From Head Structures, published by Wernet Dental Manufacturing Company, Jersey City, N. J.)

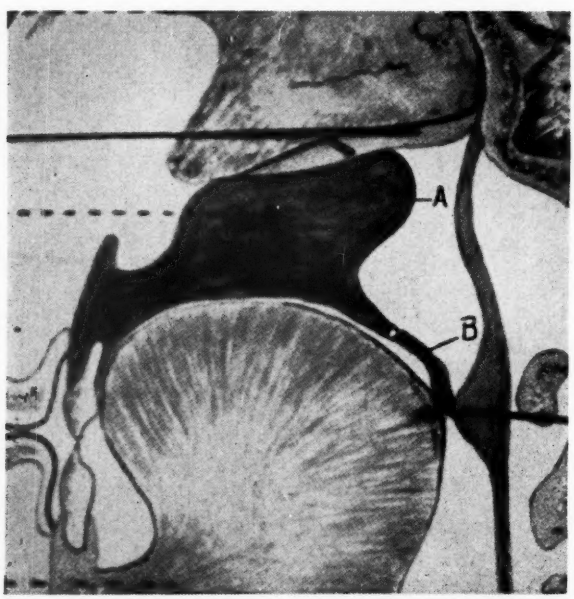


Fig. 4.—Schematic drawing. *A*, Vomer forming two separate channels of the nasal cavity; *B*, velum connected to pin lock hinge closing off the nasopharynx cavity. (From Olinger, N. A.: Am. J. Orthodontics 32:458, 1946.)

into the mouth. It permits the tongue to direct food between the teeth for mastication and toward the pharynx in deglutition. Its shape and contour influence the quality of the voice in articulation.

(5) From the standpoint of cleft palate, the soft palate with the muscles of the pharynx is important. The muscles that enter into the structures of the soft palate are: (a) levator veli palatini, (b) tensor veli palatini, (c) palatoglossus, (d) palatopharyngeus, and (e) uvulae. The soft palate is a musculomembranous curtain. Its anterior margin is attached to the posterior border of the hard palate by fibrous tissue known as the palatal aponeurosis. The posterior margin is free and curved and forms the upper boundary of the isthmus of the fauces. The uvula is suspended from the center of the curved margin.

In cases of cleft palate, the muscles of the palate and the pharynx are not always uniformly developed. A distinct protuberance (Passavant's cushion) is located in the middle of the posterior pharyngeal wall. It is also noticed that the palatal muscles and the muscles of the pharynx act as constrictors.

(6) The pharynx is a freely movable musculomembraneous tube slightly compressed in an anteroposterior direction situated behind the nasal cavities, the mouth, and the larynx. The pharynx is divided into the nasopharynx, the oropharynx, and laryngopharynx; it consists of three constrictor muscles: (a) cephalopharyngeal muscle for the superior constrictor, (b) hyopharyngeal muscle for the middle constrictor, (c) laryngopharyngeal muscle for the inferior constrictor, whose origin is confined to the larynx. It has a muscular, fibrous, and mucous coat and extends from the base of the skull to the upper border of the sixth cervical vertebra. The pharynx assists in the production of normal speech by acting with the velum and by regulating the passage of air through the nasopharynx. The pharynx is concerned with respiration, deglutition, and phonation.

## PHYSIOLOGIC FUNCTION OF THE SOFT PALATE

The soft palate performs several important physiologic functions. First, it closes the nasal passage in the act of deglutition to prevent food from passing into the nares; the same applies in coughing. Second, in speech, it also closes the nasal passages in the formation of many sounds which would otherwise have a nasal resonance if the column of air escaped into or through the nares. In fact, it would be impossible to produce such articulate sounds in a form recognizable as speech without this function. In both of the foregoing, the posterior wall of the pharynx rises and moves forward, forming a rounded ridge, to meet the velum, which is at the same time drawn upward and backward to make its contact with the posterior wall of the pharynx. In speech, this act forces the vibrating air column through the mouth only, and the resultant sound is made clear and distinct, with a quality of tone otherwise unattainable. Third, it forms a tense low arch meeting the posterior part of the tongue when that organ is drawn upward, thus closing the oral passage and leaving the nasal passage free. This function is utilized when retaining liquid or air in the mouth while

continuing to breathe through the nose; hence, it is essential in the formation of certain sounds, *g* as in *go, ng,* and *k,* for instance.

A cleft in the palate, therefore, deprives the patient of the ability to cut off communication between the oral and nasal cavities, thus interfering with deglutition and rendering this organ of speech so defective as to be incapable of producing a majority of the sounds essential to speech.

## DEFINITION OF OBTURATORS

The definition of an obturator is not complex. The appliances used by early practitioners of the fourteenth, fifteenth and sixteenth centuries were concerned with the stopping up of existing clefts in the hard and soft palates. From this operation we derive the term "obturator," from the Latin verb *obturare,* "stop up."

While, on the one hand, the obturator is an inflexible plug, or cover, held stationary in its place by the artificial denture, on the other, the "artificial velum" (from Latin *velum,* a veil) is a flexible substitute for the movable soft palate. It acts as a valve, under the control of and moving with the muscles, to perform the function of closing the air passages as required in speech and deglutition.

While the term obturator is popularly applied to all palatal appliances, the artificial velum is by its nature specifically restricted to use for clefts of the soft palate only. The obturator may also be put to the same use, but it is the only recourse for closure of the hard and soft palates. When combined with an artificial velum, that part of the supporting denture covering or filling the fissure of the hard palate comprises the obturator.

## CLASSIFICATION OF CLEFT PALATES

The term surgical prosthetics is used to designate the mechanical restoration of lost tissue of the intraoral and extraoral structures. Generally, it is that branch of dentistry which aims to reconstruct congenital and acquired defects by appliances closely associated with surgical treatment. Benefits from this type of service are numerous, as follows: to restore function as far as possible, to improve appearance, speech, and the morale of these unfortunate patients, and so forth.

As an intraoral defect, the palatal defect may be congenital or acquired. The congenital cleft palate is one of the principal oral defects. Acquired cases result from trauma, injuries, disease, and postoperative failures.

The congenital cleft palate may be classified as follows: Class I, fissure in the azygos uvulae; Class II, fissure in the uvula; Class III, fissure in the soft palate; Class IV, fissure in the soft and hard palates; Class V, unilateral cleft, fissure in the soft and hard palates through the alveolar ridge at the junction of the maxilla and premaxilla, accompanied by a cleft lip; Class VI, bilateral cleft, fissure in the soft and hard palates through the alveolar ridge, involving both sides of the maxilla, freeing the premaxillary bone with a double cleft lip (Fig. 5).

## ETIOLOGY

There is much speculation, but very little definite knowledge, regarding the etiology of cleft palate. A glance at the literature will show how voluminous it is on this point. Lip and palate clefts occur in about one in every 800 to 1,200 births and more often on the left than on the right side. There are said to be many predisposing causes. In the white race, these defects may occur without regard to geographical or tribal distinctions. Among Negroes, they are rare. Males are more subject to these deformities when the combined lip and palate clefts are considered. Boys are less subject to the minor palate clefts but far more subject to the complete lip and palate clefts. Jackson and Jackson[2] stated that heredity probably plays an important part. The influence of maternal impressions is a superstition. Most physicians agree that defective nutrition or general weakness during pregnancy may be an important factor in delaying union.

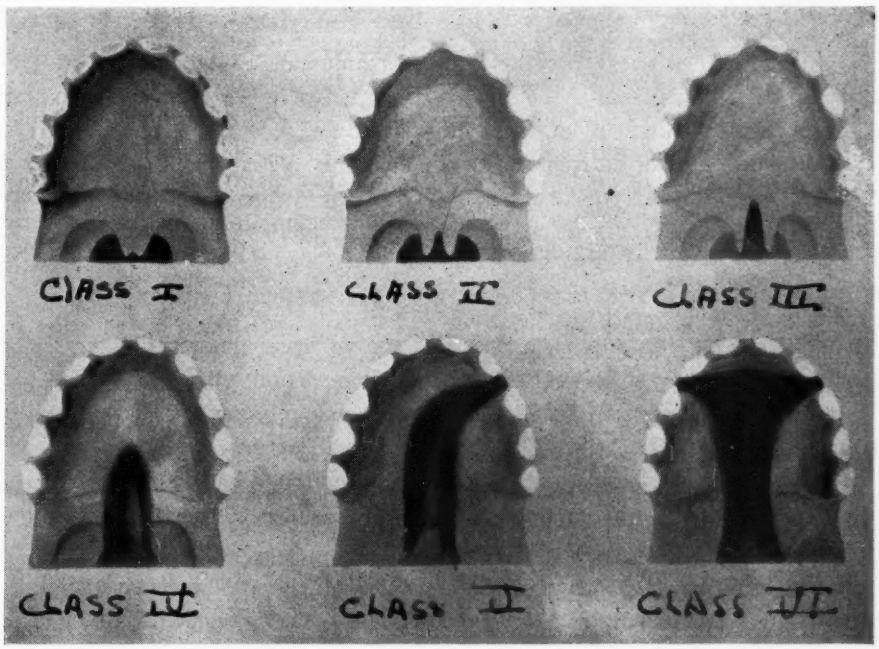


Fig. 5.—Cleft palate classification. (Original drawing, from Olinger, N. A.: Am. J. Orthodontics 32:457, 1946.)

Some hold to the mechanical theory that pressure of the tongue on the palate, due to the flexed position of the head, may be a factor in preventing union. Others believe that supernumerary teeth may be a cause. It is interesting to note that associated defects, such as club foot, a sixth finger, or congenital heart lesions, are not common.

## HISTORY OF PATIENT

The history of the patient must be carefully evaluated. In properly selected cases, surgical restoration of the cleft palate is the preferred procedure.

The results usually obtained by a skillful oral or plastic surgeon are remarkable. However, there are several contraindications to successful surgical treatment. Some of the determining factors are: age of the patient, extensiveness of defect, inability of grafts to take, secondary defect caused by excessive postoperative tension, and health of the patient.

The decision as to the type of appliance to be used in a given case to achieve the best results involves a thorough knowledge of the normal anatomy of the missing or defective parts and their functions, the intelligent comprehension of the principles upon which the vela and obturators are constructed and the manner in which these devices operate, and the case history, which will bring out such facts as the patient's age, the nature of the defect (whether acquired or congenital), and the surgical record including the time of the operation, if any, and the circumstances surrounding it.

## EXAMINATION AND ROENTGENOGRAMS

The prognosis of every prosthetic case is influenced by the diagnostic judgment of the prosthodontist. A clinical examination of the mouth, x-ray examination, and a vitality check-up of the teeth should be recorded. Particular notice should be made of deformities, teeth, occlusion, lips, heredity, history of surgical procedures, oral and pharyngeal tissues, and speech. One also takes into account the age, mentality, environment, and training potentialities of the patient.

## PHYSIOLOGIC FUNCTION OF THE POSTPHARYNGEAL EXTENSION

In constructing the appliance, one is building upon the physiologic function of the postpharyngeal extension. The hard palate section, which is clasped to the teeth, is constructed first. This section supplies any missing teeth and gives contour and support for the lips. The artificial velum, or postpharyngeal extension, is then constructed; it should extend to the posterior pharyngeal wall, about 5 mm. below the cushion of Passavant's pad. When the velum is completed, it is united to the anterior section of the appliance.

In the complete cleft where the vomer and turbinate bones are absent, an artificial vomer is constructed. The vomer serves the specific physiologic functions of collecting particles of moisture from inhaled air, allowing this moisture to trickle down the throat to lubricate the pharynx, and acting as a resonator to improve tonal quality.

The postpharyngeal extension serves a specific physiologic function. It affords the means for closing the nasal passage definitely and with sufficient completeness to interrupt and direct the column of air which is set in vibration in the larynx as it issues from the throat. When the artificial velum is in use, the joint and the wings of the velum lie close across the opening on the superior or nasal surface, hugging the palate pharyngeal muscle. In construction, the velum is also extended posteriorly until it almost touches the muscles of the pharynx when they are in repose. Both the wings of the velum extend beyond the boundary of

the cleft and rest on the superior surface of the soft palate, covering about one-eighth or one-quarter inch of its surface. This artificial velum enables the normal palate (part of the soft palate and the pharyngeal muscle) to function in an up-and-down motion, according to the requirements of articulation. By constructing an artificial velum light in weight with thin lateral wings, the velum will function with free mobility as a natural organ.

### AID TO SPEECH

Probably the most important function of an obturator and an artificial velum is to aid the speech of the afflicted patient. The organs used in speech can be classified in the following way: the power mechanism, the voice-producing mechanism, the resonating mechanism, and the articulatory mechanism. The normal action of these organs may be summarized in this way: The source of power for speech is the air coming out of the lungs. The air is converted into voice by the action of the vocal cords. The voice is amplified or resonated by the throat, mouth, and nose. The voice is modified into the vowels and consonants by the muscles of the soft palate, tongue, jaws, teeth, and lips.

The chief difficulty in articulation comes from the defective soft palate. Because the soft palate does not prevent the air from entering the nose, it is difficult to build up enough pressure in the mouth to make such sounds as *p-b, t-d,* and *k-g.* Other sounds like *s* and *z* are also wrongly uttered through the nose.

After the palate has been repaired or restored mechanically, the first problem is to teach the patient to use the artificial velum by exercising the palatal muscles. To produce normal speech, the muscles of the soft palate must contract to "shut the door" from the throat into the nasal cavities so that the air stream will come out through the mouth.

Exercises useful in developing palatal function are gargling, blowing pinwheels, blowing a whistle, and blowing a light Pingpong ball across a table. A speech therapist, a speech clinic, a trained schoolteacher, or even parents who have been properly instructed can teach the speech sounds.

### PSYCHOLOGIC HANDLING OF A PATIENT

Social adjustment is one prerequisite in the psychologic handling of child patients. The child with a cleft palate will be adjusted and reasonably happy if his parents are properly conditioned to the situation.

It must always be borne in mind that the cleft palate patient finds personal and social adjustment extremely difficult. He is gravely handicapped in competing with normal persons to earn a living, and he is at a serious disadvantage in winning the respect of his associates or in forming close and rewarding friendships. Therefore, early correction to obviate as much as possible of the physical and mental injury is extremely essential.

With this background of theory and facts behind us, we can now take up the prosthetic construction of obturators and artificial vela.

## Part II

We have had the greatest success in restoring complete function to a patient with congenital Class V cleft palate by means of a hinged appliance. A Class V cleft is a cleft which begins at the uvula and extends anteriorly through the soft palate, hard palate, and premaxillary area of the maxilla into the mucolabial fold, resulting in a cleft lip at its termination (see Fig. 5).

### TECHNIQUE

*A. Study Cast.*—A careful radiographic and clinical examination of the mouth should be made and any noticeable defects kept in mind when the impression is to be made. An impression for a study cast is made in either hydrocolloid or alginate in a stock tray. Modeling compound or plaster of Paris should be avoided, for the obvious reason that they will flow into undercuts and harden, thus making it impossible to remove the impression without seriously injuring the patient's mouth.

On the study cast, the size of the denture-bearing area and the approximate location for the hinge are determined. Upon comparison of the study cast and the mouth, there will be noted such discrepancies as distortion of the soft structures in the posterior portion of the mouth, incomplete impression of the cleft, and overextension in the buccal and labial folds.

*B. Working Cast.*—A perforated impression tray of shellac baseplate material is constructed (Fig. 6). This is built over a spacer, with stops to allow for sufficient thickness of impression material. Modeling compound is added to the posterior border of the tray and muscle-trimmed in the mouth until it extends to the posterior pharyngeal wall. In that way all the required nasopharyngeal and oropharyngeal structures will be included in the impression (Fig. 7).

In anterior clefts, or clefts not extending beyond the terminus of the hard palate, no gagging difficulties are experienced by the patient. When the cleft extends into the nasopharyngeal area, however, it may become necessary to employ local or topical anesthesia in the posterior palatine foramina. Where the tissues are not sufficiently desensitized by the injection in the posterior palatine foramina to eliminate the gagging reflex, a lump of sugar saturated with a drop of spirits of camphor slowly dissolving in the mouth will prevent gagging.

The patient is advised to breathe through the mouth. The center of the tray is loaded with alginate in sufficient bulk to insure adequate coverage of all necessary anatomic detail. With a spatula, sufficient alginate is carried into the cleft to fill it. The loaded tray is gently seated in the mouth by bringing the posterior portion of the tray into position first.

In this way, the impression material is forced upward and anteriorly into the cleft, thereby preventing an excess of the material from escaping into the pharyngeal region. The tray is finally seated with a vibrating motion, to eliminate bubbles, and is maintained in the desired position until the alginate sets thoroughly. The seal is broken carefully in the region of the tuberosity in the mucobuccal

fold, and the tray with the impression is removed. On removal, the impression will tear at the juncture of the cleft and the palate, leaving the cleft filled with alginate. This remaining portion is removed by easing it posteriorly and downward with the blade of an instrument. The segments of the impression can be restored to their proper position and held with small, straight pins. The impression is boxed, and a cast of stone is made. This becomes the working cast.

Fig. 6.

Fig. 7.

Fig. 6.—Perforated shellac tray with compound or wax added to extend to the posterior pharyngeal wall.
Fig 7.—Design of the case for a partial denture.

The appliance is designed on the working cast. When teeth are present, the abutment teeth, the type of arch, the width of the cleft, and the length of the remaining hard palate are considered (Fig. 7).

A plaster or alginate impression is made of the lower teeth and poured in low-fusing metal.

### WORKING CAST CORRECTION

The maxillary working cast may require correction. This cast is compared with the mouth. We note that, although all the necessary structures have been

included, there is still a slight distortion of the margins of the cleft in the hard palate area and a displacement of the halves of the uvula in the soft palate area. To correct the hard palate, pink baseplate wax is accurately adapted to the cast posteriorly as far as the junction of the hard and soft palates. This wax pattern is carried to the mouth where, unsupported, it should adhere to the palatal tissues while the patient swallows.

Dislodgment of the pattern indicates that it does not fit the margin of the cleft which was distorted by the impression. The pattern is removed from the mouth, and the wax along the margins of the cleft is softened by submerging that area in water at 120°F. The pattern is quickly returned to the mouth and seated firmly so that the softened wax may be adapted by the tissue along the margins of the cleft.

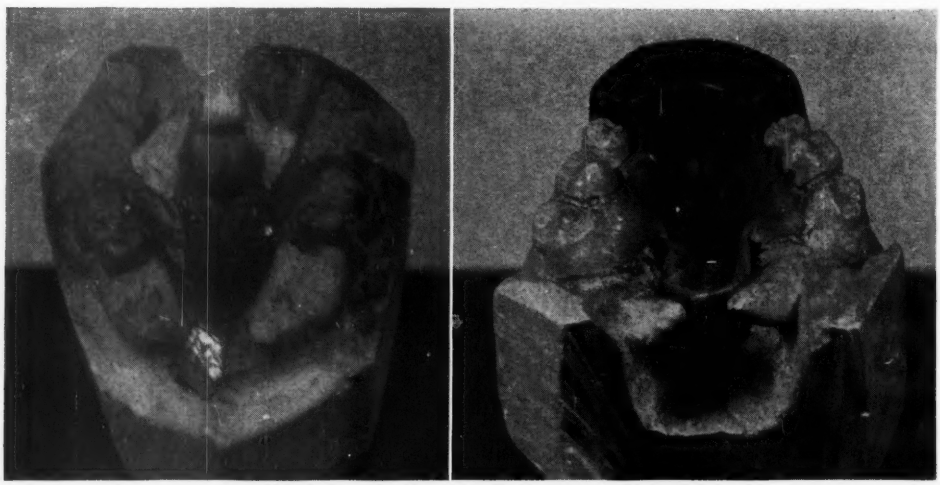

Fig. 8. Fig. 9.

Fig. 8.—Hard wax is filled into the cleft and contoured to conform with the dome of the palate.
Fig. 9.—Baseplate and occlusion rim as outlined.

Following this initial correction, soft Everett's wax is applied to the wax baseplate, and the pattern is returned to the mouth and trimmed by the tissues. This is repeated as many times as required so that the patient will retain the pattern in position while swallowing.

After being corrected, the wax pattern is replaced on the cast. It will be observed that the corrected pattern does not come in contact with the cleft margins of the cast. The cast is corrected by sealing the gingival margins of the wax pattern to the cast and by vibrating a thin mix of artificial stone into the space between the corrected wax pattern and the cleft of the moistened cast.

The uvula and soft palate areas are not corrected at this time. (This will be done later at the try-in stage.) Next, Plasticine is used to close off the cleft in the hard palate area and is contoured to the dome of the palate (Fig. 8).

### PALATAL AND OCCLUSION RIM

The baseplate and occlusion rim are constructed on the stone cast, as outlined on the study cast (Fig. 9), with which centric relation and vertical dimension are determined. By means of a face-bow, these registrations and casts are mounted on an anatomic articulator. The proper mold and shade of teeth are selected, set up, and tried in. The occlusion is corrected in the mouth by grinding.

### THE PALATAL EXTENSION

The baseplate is conventionally contoured in the hard palate area, but in the soft palate area a spadelike extension is made projecting posteriorly to the junction of the soft palate and uvula muscles (Fig. 10). This is important because it locates the position of the pin lock hinge. The posterior pharyngeal extension or velum will be attached to the hinge.

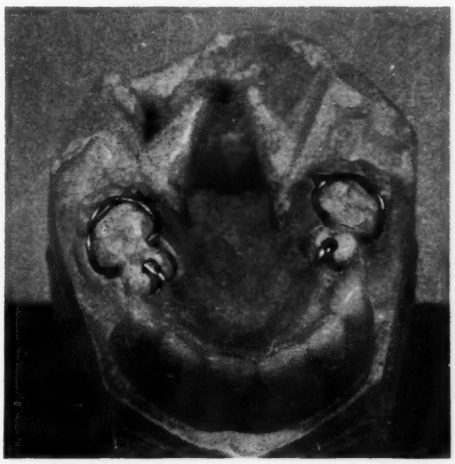

Fig. 10.—Clasps contoured and bent into shape; teeth set up for try-in.

As accurate as the impression was, there is still not the accuracy required of the movable palatopharyngeal tissues involved. Consequently, the baseplate with the setup on it, which has been roughly trimmed on the cast, is accurately trimmed in the mouth to the juncture of the hard and soft palates. The portion which occludes the cleft posteriorly, and to which the posterior pharyngeal extension is to be attached, is trimmed by the medial portion of the levator and tensor palati muscles. This is done by muscle trimming with soft Everett's wax. The muscles are manipulated by having the patient swallow, yawn, and turn the head to the right and left and up and down.

At this time, the clasps for the retention of the appliance are constructed and attached to the trial obturator. Careful consideration must be given to the choice of clasps. Where the remaining teeth closely approximate each other, the Jackson crib clasp is indicated; where the teeth are separated, the Bonwill or Gillette clasp is ideal. In most cases, two or three clasps are sufficient to retain the denture. After the clasps are attached to the trial base on the cast, the assembly is returned to the mouth to check the esthetics and occlusion.

## PIN LOCK HINGE

A pin lock hinge serves to attach the artificial velum, or posterior pharyngeal section, to the palatal section of the appliance (Fig. 11). The female portion of the hinge is waxed to the palatal extension of the trial base. It must be accurately positioned at the distal end of the palatal extension so the male portion of the hinge will fit in the exact center of the pharyngeal opening (Fig. 12). The hinge must be located so it is parallel to Passavant's pad.

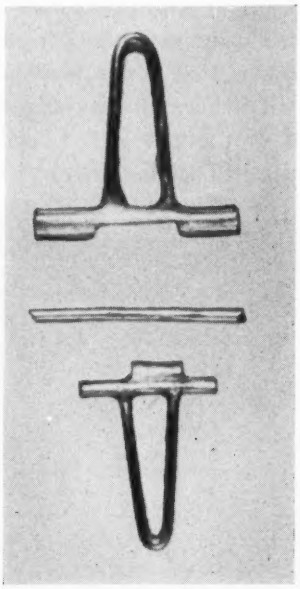

Fig. 11.—Pin lock hinge. Female part above, male part below.

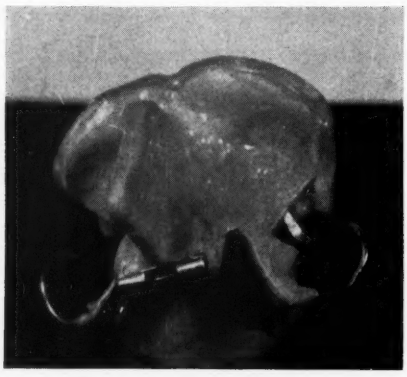

Fig. 12.—Female part of the hinge attached to the posterior portion of the denture.

## CONSTRUCTION OF THE VOMER

The vomer is constructed after the cast has been corrected, the try-in completed, the occlusion perfected, the palatal extension determined, and the position of the hinge located. The trial base now constitutes a trial obturator.

The pattern for the vomer is made by forming a double thickness of base-plate wax into a rectangular shape, similar to that of the missing portion of vomer, and luting it to the nasal aspect of the trial base. While this wax is still in a moldable state, the trial obturator is gently eased into position in the mouth. The trial obturator is then removed, and the excess wax is trimmed away from the periphery of the vomer pattern. A border of soft carding wax is then traced on the periphery of the vomer patern. The trial obturator is returned to the mouth where the carding wax is trimmed by the tissue. It is removed, and the excess carding wax is trimmed off with a scalpel. Carding wax is traced

Fig. 13.

Fig. 14.

Fig. 13.—Cast cut through, allowing free space for the vomer pattern. It is boxed and ready to be filled in with stone.

Fig. 14.—The velum, or the posterior pharyngeal extension, approximates the Passavant pad or superior constrictor muscles. It is resting upon the cast of the pharyngeal muscles. These muscles have a range of 10 to 12 mm. of up-and-down movement.

onto deficient areas, and the trial obturator is reinserted. This procedure is repeated until there is no excess or deficiency and the vomer pattern on the trial obturator conforms to the remnant of the vomer.

The trial obturator is reseated in the mouth to make sure there is no interference with the soft tissues or with the action of the palatal muscles. If there is no interference, the cast is then cut through its center to allow free space for the vomer pattern (Fig. 13). The trial obturator is seated on the cast. The cast is moistened and boxed. Stone is vibrated into the space around the vomer pattern to modify the form of the cast to that pattern. The cast is then remounted on the articulator. Further corrections of occlusion and waxing may be made before processing. The obturator portion of the appliance may be made of vulcanite, acrylic, gold, or a cobalt-chromium alloy.

The completed obturator portion of the appliance should be worn by the patient for some time to permit adjustments wherever they may be necessary. After the patient has become accommodated to the new palatal-retaining appliance, the pattern for the posterior pharyngeal extension, or velum, is made.

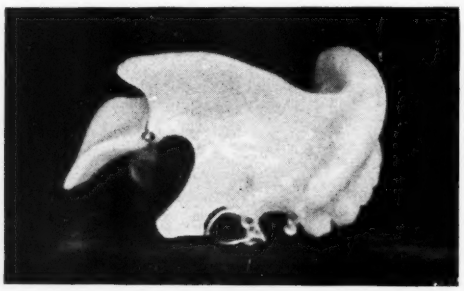

Fig. 15.—The completed appliance, processed in acrylic.

## THE ARTIFICIAL VELUM

The female portion of the pin lock hinge is imbedded in the denture when it is processed. The male portion of the hinge is attached to the fixed part of the hinge, so that it will hang posteriorly in the cleft in the soft palate. A triangular piece of baseplate wax of sufficient width to contact the walls of the cleft is attached to the loop on the hinge (see Fig. 11). It should contact the pharyngeal walls and extend to Passavant's pad.

The appliance is placed in the mouth, and observations are made of the relations of the wax to the pharyngeal walls and to Passavant's pad. The patient is directed to swallow, turn the head from side to side, and tip it forward and backward.

The appliance is removed, and a careful examination is made of the pharyngeal extension. Slightly more than the excess wax is removed, and its edges and surfaces are then traced with carding wax. The appliance is replaced in the mouth, and the exercises previously noted are repeated several times. These procedures are continued until the velum extends to Passavant's pad and until

the palatopharyngeal muscles grasp the velum to shut off the nasopharyngeal cavity when the patient swallows. The velum should form a seal which will prevent air, fluid, or food from passing into the nasal cavity (Fig. 15). The form of the velum is further perfected by directing the patient to exercise by pronouncing the gutteral sounds, such as *k*, *g*, and *q*. Any excess carding wax is removed, and, if there is a deficiency, more wax is added. When the wax velum functions correctly and when the patient indicates that it is comfortable, it is processed in metal or plastic.

## SPEECH INSTRUCTION

The completed and assembled appliance is inserted in the mouth, and any necessary corrections are made. The patient may require several visits for minor adjustments. He is then taught to practice phonetic sounds, such as the vowel *a* in ate, at, and ah and all the plosives, *g* as in give, *k* as in king, and *q* as in quite. The object of these exercises is to strengthen and develop the pharyngeal and palatal muscles so they will firmly and involuntarily close around the artificial velum. This will completely prevent the vocalized air from escaping through the nasal passages.

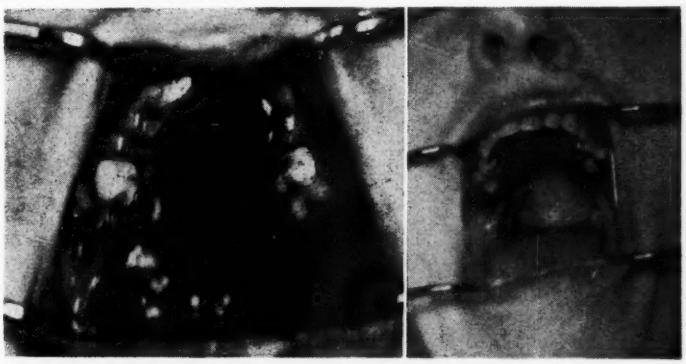

Fig. 16. Fig. 17.

Fig. 16.—A Class V cleft palate, with one bicuspid and molar on each side remaining.
Fig. 17.—The obturator in position showing the hinged velum resting on the pharyngeal muscles closing the nasopharyngeal cavity.

Improved speech and articulation depend greatly upon the proper functioning of the patient's muscles and upon the desire and will to continue the efforts until a measure of success is attained. It is essential that speech training be given by a speech therapist who understands the speech problems of a patient with a cleft palate.

Figs. 16 to 19 illustrate a typical Class V unoperated cleft palate and its treatment. The obturator was constructed to restore the missing teeth and the vomer. The hinged velum was used to close the cleft in the soft palate. Perfect speech resulted from this treatment after the patient had received speech training.

## CONCLUSION

Common sense and ingenuity are necessary in the prosthetic treatment of patients with cleft palates. There are no set rules to follow. Only rarely are two cases exactly alike. The prosthodontist may obtain satisfactory results for one patient, while the results for another will be disappointing, despite his best efforts. The treatment of patients with cleft palates is a challenge to, and a responsibility of, prosthodontists.

Fig. 18.—The obturator and vomer with a pin lock hinge velum attached to denture.

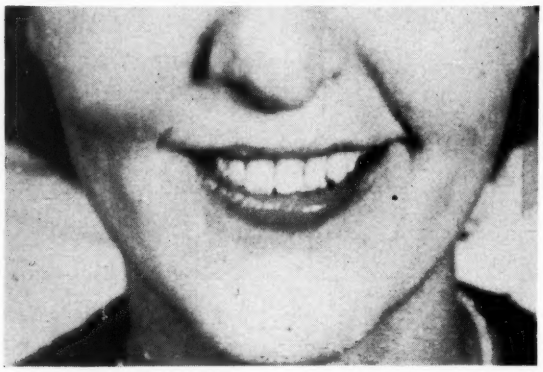

Fig. 19.—The obturator inserted.

The maximum success should be based on a long-range program under the auspices of a reliable agency. Such a program should enlist the combined efforts of the oral surgeon, prosthodontist, orthodontist, nurse, psychologist, speech therapist, and the patient's informed and understanding parents.

## REFERENCES

1. Orban, Balint: Oral Histology and Embryology, ed. 2, St. Louis, 1949, The C. V. Mosby Company, pp. 31, 32, and 58.
2. Jackson, Chevalier, and Jackson, C. L.: Diseases of the Nose, Throat, and Ear, Philadelphia, 1945, W. B. Saunders Company.

*Additional*

Sicher, Harry: Oral Anatomy, St. Louis, 1949, The C. V. Mosby Company, p. 281.
Olinger, N. A., Katz, T., and Singer, L. E.: Psychiatric and Surgical Prosthetic Study of Cleft Palate Patient, D. Items Interest **63**:828, 1941.
Olinger, N. A., and Axt, A.: Surgical Prosthesis of Oral and Facial Defects, Am. J. Surg. **31**:24-37, 1936.
Olinger, N. A., Katz, T., and Singer, L. E.: Facial Prosthetic Reconstruction, D. Survey **20**:232-235, 1944.
Olinger, N. A., and Axt, A.: Prosthetic Restoration Following Surgical Removal of Maxilla, D. Items Interest **58**:920-923, 1936.
Olinger, N. A.: Surgical Prosthesis, Am. J. Orthodontics **28**:222-238, 1942.
Olinger, N. A.: Eugenic Aspect of Cleft Palate and Other Facial Deformities, J.A.D.A. **31**:1431-1434, 1944.
Olinger, N. A.: Oral Defects in Their Relation to Defective Speech, Am. J. Orthodontics **32**:469-471, 1946.
Olinger, N. A.: Prosthetic Restoration of Congenital Cleft Palate, Am. J. Orthodontics **32**:456-468, 1946.
Webster, Richard C.: Cleft Palate Treatment, Oral Surg., Oral Med. & Oral Path. **1**:943-980, 1948; **2**:99-153, 1949; **2**:485-542, 1949.

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# METHODS FOR EVALUATING KNOWLEDGE AND ABILITY IN THE FIELD OF PROSTHETICS

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A DISCUSSION of the methods for evaluating knowledge and ability in the field of prosthetics seems to me, as a past member of a State Board, to be one of considerable importance to the profession of dentistry at this particular time. We are faced on all sides with those who would make inroads on the practice of dentistry either through selfish motives or in the guise of social reform, and the prosthetic field is most frequently under attack.

The subject of prosthetic dentistry, in which we will throughout this paper include full and partial dentures and crown and bridgework, is one which has advanced and expanded so greatly, and the techniques and methods are so varied, that it has become a real problem from the standpoint of the schools to teach and of the State Boards to examine. Realizing the limited time available to the schools to cover all phases of prosthetics so as to provide clinical experience sufficient to assure proficiency, the Boards are faced with the problems of determining what minimum requirements of proficiency should be expected and how to determine if the candidate for licensure possesses these qualifications. State Boards are concerned that those licensed will possess sufficient knowledge and ability in prosthetic dentistry so that they can and will conduct themselves in the practice of dentistry in such a manner as to render the public a satisfactory service. This will maintain the prestige of dentistry in this field so as to preclude any possibility of others with sinister motives attempting to take over any part of this important phase of dentistry.

It is then incumbent upon us, as dental educators and dental examiners, to place sufficient emphasis on the subject of prosthetic dentistry to guarantee its performance in a manner which will leave no room for intrusion. How can this best be done? That is the question.

## STATE BOARD EXAMINATIONS

The different State Board examinations in prosthetics have varied in their requirements as greatly as have the teachings of the several schools. Some have included crown and bridge procedures, but generally the examinations have been concentrated on the construction of a full denture from the impression to the final setup. It is questionable to the speaker as to whether this requirement actually is of any real help in measuring the ability and knowledge of

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the candidate in the field of prosthetic dentistry or in evaluating the quality and quantity of the teaching of this subject in the various schools. Since it is our belief that State Boards can help the schools to develop their teaching in a manner to meet present-day demands, it may be that our boards should require, particularly of recent graduates, a greater knowledge of modern techniques and the ability to apply them.

The graduates of all schools should be prepared broadly enough to pass all State Boards, and schools should be able to teach without being hamstrung by being required to point their students for certain local or near-by State Board requirements. Surely there must be certain fundamental knowledge and skill in the field of prosthetics which our boards should expect all graduates to possess and which will be within the capabilities of schools to teach.

Should we not expect a graduate to be able in full denture construction (1) to take an adequate impression on which to construct a full denture, (2) to obtain proper recordings for the establishment of vertical dimension, centric relation, and eccentric movements of the mandible, and (3) to select and set up teeth and secure balanced occlusion? In partial denture construction should we not expect a graduate to be able to (1) plan a partial denture, (2) prepare a mouth to a reasonable degree to receive such a denture, including the balancing of occlusion and preparation of teeth for occlusal rests, (3) make an adequate impression for a partial denture, (4) select and set up teeth, and (5) instruct the technician properly as to requirements of the case?

In crown and bridge, since it is generally conceded that a full coverage crown is a good bridge attachment and is the one most used, should we not expect a graduate to be able to prepare for and construct reasonably well such an attachment? And since bridgework affecting anterior teeth requires the use of an attachment which will satisfy esthetics as well as provide adequate retention, and since it is generally agreed that the three-quarter crown or Carmichael-type restoration provides such an attachment, should we not expect a graduate to be able to prepare for and construct such a crown?

If a graduate has been trained to meet the demand which the preceding requirements would fill, he would be prepared to meet fairly well most of the problems which he would face in practice in the prosthetic field. This is the concern of State Boards.

How then in a limited time can a State Board ascertain whether a candidate for licensure possesses this fundamental, necessary knowledge and skill? We cannot require a candidate to cover the whole field, but we must select certain exercises which will demonstrate such ability.

I believe that we can measure this skill reasonably well if we require in full denture construction (1) ability to take an adequate full impression and recognize important landmarks and (2) the recording of vertical dimension and centric relation. (*Note*: There would seem no point in carrying this procedure to the setup as it could be assumed that with correct recordings this could be accomplished. Thus, State Boards might better utilize this time for other demonstrations.)

In crown and bridge, if we require the preparation for the construction of a full coverage crown to the point of investment, this would demonstrate the knowledge of tooth anatomy and skill in construction in this phase. This could be adequately tested by the typodont method. The selection by the examiner of either a full crown coverage or a three-quarter anterior crown would require the candidate to be prepared to do either of these important bridge attachments.

As for a partial denture test, I believe the important elements in this field can be included in a comprehensive mouth diagnosis and treatment planning examination such as we now have in New Jersey by adding the planning, surveying, and designing of a partial denture on a cast furnished by the board.

If State Boards and dental schools are to cooperate in their efforts to continually improve dental education, and so dental practice, we must come to a general agreement as to minimum requirements. This can be approached more realistically if State Boards sit down more frequently with dental educators and learn their problems, and vice versa. The New Jersey Board is doing that. It is finding many of our fallacies and trying to correct them. With the changing of Board personnel, this must be a continuous effort, and the lessons learned by one Board must be passed on to those succeeding if we are to continually advance. The problem of accurately evaluating candidates for licensure in the larger states is more difficult than in the smaller states. The large number of candidates presents a problem in the mechanics of setting up facilities by which a few men can, with some degree of fairness and accuracy, measure the qualifications of 50 to 100 or 200 candidates. Our secretary has proposed for study a method by which larger states might meet this situation.

It is admittedly difficult and often unfair to try to judge a candidate's qualifications in prosthetics and operative dentistry on the basis of a single or a very few clinical exercises performed under examination pressure. Dr. Wilson proposes that for recent graduates it may be possible for State Boards to accept, in lieu of the operative or prosthetics examination, a certification of the school from which the candidate graduates that the candidate was in the upper one-half of his class in that clinical subject. This certification would include a list of his accomplishments in that department. I believe this offers some promise for the larger states, although it presents some questions as to its successful functioning. In its favor, I would say that it would reduce the number of candidates greatly and allow the examiners more time to evaluate those who had to be examined; it would give the candidates more time with the heavy burden removed from examiners; it would obviate the danger to a candidate who had demonstrated beyond doubt to his professors that he was about average and safe from possible "examination mishaps" or "fatalities"; it would certainly furnish some incentive for students to do more and better clinical work in school; and it would furnish Boards a picture of the clinical accomplishments of the students of the various schools.

On the negative side, there may be some temptation on the part of some instructors to push a student into the upper one-half; schools may find it a

burden to furnish the necessary records; Boards would not see the best students in action; and there may be a feeling of discrimination by those in the lower one-half of the class.

I believe, however, it would be worth a try. With the Boards' retaining the mouth diagnosis and treatment planning examination for all candidates and with the written examinations all being pointed toward the dental application of the subjects as our Board now does, we would still get a good view of the qualifications of all candidates.

## CONCLUSION

In conclusion, State Boards should set their requirements so as to demonstrate that candidates are able to do proficiently, by an acceptable modern technique, those prosthetic procedures which are common to modern dental practice. This can be demonstrated in the taking of an adequate full mouth impression and the recording of vertical dimension and centric relation, in crown and bridge by the preparation for construction of a full coverage crown or a three-quarter anterior crown to the point of investment by the typodont method. Planning, surveying, and designing of a partial case could be tested as part of a comprehensive mouth diagnosis and treatment planning examination. Schools should impress students with the importance of prosthetics and a good modern knowledge of it for its survival as a part of dental practice. Certification by the schools of the students in the upper one-half of their class in clinical prosthetics and operative dentistry might be an aid to larger states and offer greater incentive to the students.

Let us not minimize the importance of practicing good prosthetics. A good State Board examination in prosthetics can contribute to the improvement of dental education in this field. There is much to be done in this direction.

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# News and Notes

## ANNOUNCEMENTS

The meeting of the American Denture Society will be held on February 2 and 3, 1952, at the Congress Hotel in Chicago.

The meeting of the American Academy of Restorative Dentistry will be held on February 2 and 3, 1952, at the Stevens Hotel in Chicago.

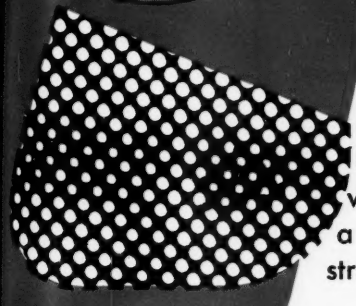
The annual Postgraduate Clinic of the District of Columbia Dental Society will be held on March 9 to 12, 1952, at the Shoreham Hotel, Washington, D.C.

The meeting of the American Association for Cleft Palate Rehabilitation will be held on April 25 and 26, 1952, at the Chase Hotel, Washington University Dental and Medical Colleges, and Barnes and Children's Hospitals in St. Louis, Mo. Those who may wish to present papers or demonstrations may contact the Chairman of the Program Committee, Dr. Cecil R. Conroy, First National Bank Building, Belleville, Ill.

The Postgraduate Courses of the School of Dentistry of the University of Pennsylvania is offering the Third Mid-Atlantic States Seminar in Oral Medicine at Skytop Club in the Pocono Mountains in Pennsylvania May 11 to 16, 1952. For further information write—Dr. Lester W. Burket, Director, Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce Street, Philadelphia 4, Pennsylvania.

# the first "vacuum fired porcelain" teeth

In vacuum firing the internal and external gases created at the high temperatures at which



porcelain must be fired, are drawn off. The porcelain that results is a dense, homogeneous solid substantially free from voids, air bubbles and blisters. It is a porcelain that is definitely stronger, denser and more "alive" in appearance.

NEW IN EVERY WAY

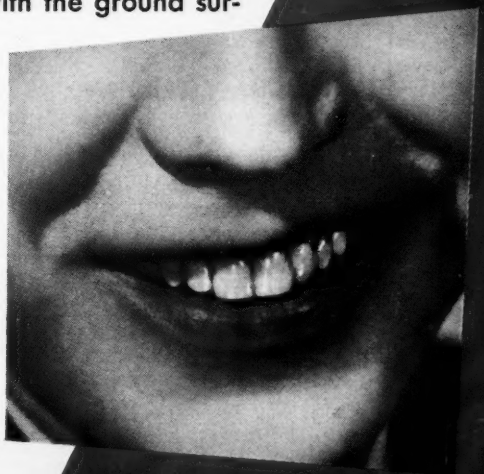
## trubyte Bioform® teeth

the first "vacuum fired porcelain" teeth

**JUDGE FOR YOURSELF THE STRENGTH AND DENSITY OF TRUBYTE BIOFORM TEETH.**

Grind a **Trubyte Bioform Tooth**. Feel its texture. Then examine the ground surface of the tooth under magnification and compare it with the ground surface of any other tooth. After you have polished the tooth with a rag wheel and pumice, again observe it under magnification.

**SEE FOR YOURSELF HOW REALLY DENSE ARE TRUBYTE BIOFORM TEETH.**



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